Electrochemical Industry

VOL. I. PHILADELPHIA, APRIL 1, 1903. NO. 8.

Electrochemical Industry

Published on the first of each month by the

ELECTROCHEMICAL PUBLISHING COMPANY,
[*Incorporated.*]

CITY TRUST BUILDING, PHILADELPHIA, PA.

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Long Distance Telephone 3-51-24.

Subscription Price: $2 per year, postpaid to any part of the world. Single copies, 25 cents.

SUBSCRIPTIONS MAY COMMENCE FROM VOL. I, NO. 1 (SEPT. 1902)

ADVERTISING RATES GIVEN ON APPLICATION.

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Entered October 24, 1902, at Philadelphia, Pa., as Second-Class Matter, under Act of Congress of March 3, 1879.

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THE NEW YORK MEETING OF THE AMERICAN ELECTROCHEMICAL SOCIETY.

The coming general meeting of the American Electrochemical Society is the first to be held in New York City. After the meetings at Philadelphia, as the birth-place of the Society, and at Niagara Falls, as the greatest center of electrochemical industries in the world, it is, of course, New York's turn. New York City is not only the metropolis of the United States, but also the official seat of all the national engineering societies—with the only exception of the American Electrochemical Society. There can be no doubt that in due course of time this Society will also transfer its seat to New York City, and, in view of this fact, the first meeting held by the Society in New York City is of special significance. It is a question open to discussion whether a large city is the most suitable place for a convention of an engineering society. In the present case, however, the elaborate programme which we present in full on another page of this issue, leaves no doubt that the convention will be a full success and a very enjoyable affair. The programme contains a great number of papers on interesting and important subjects, and as, for the first time in the American Electrochemical Society, some of the papers will be printed in advance, we trust the discussion will bring out valuable information. The presence of Dr. Walter Nernst—famous alike as the theorist of concentration cells and as the inventor of the Nernst lamp—gives an international flavor to the meeting. There is every reason to hope that the New York meeting will turn out a success as great and enjoyable as the meetings at Philadelphia and Niagara Falls, and we hope that it will strengthen among its members the esprit de corps—the sentiment that we are all workers in the same field and enlisted in the same cause.

The New York meeting will be the *second annual* meeting—in other words, the Society now enters the second year of its life. It may be proud of the work which it has accomplished in its first year. We need to refer only to the two volumes of Transactions, which it has published, and to the membership list, which is increasing far beyond the first fondest hopes of the founders. It is significant that a large number of well-meaning scientists and engineers who, a year ago, opposed the foundation of the Society, have now become members. In the first year of its life the Society has proven to everyone that it has a mission to fulfill, and that its members are earnest in their purpose to do their duty.

The New York meeting will be the *third general* meeting of the Society. That means that the first year's work was done in only *two* large meetings. Probably the usefulness of the Society would be enhanced if more meetings would be held, at shorter intervals; of course, a meeting of one evening could be of a local character only, and this brings up the question of

the advisability of local branches of the American Electrochemical Society. New York, Niagara Falls, Philadelphia, Cleveland and Madison, Wis., have enough resident members to warrant the foundation of local branches. In various other national societies this institution of local branches has proven very successful. Of course, these local branches should always be under the control of the national Society, and the two general meetings per year should be held in future as heretofore. We think the matter is of sufficient importance to warrant a discussion by the members at the New York meeting.

"SILOXICON."

Before the simple experiment of subjecting commingled silica and carbon to intense heat had been tried, it would have been difficult to realize that within a few years a literature equal in extent to many volumes would cluster about the reaction. The far-reaching commercial value of a seemingly simple discovery is a familiar experience, but that a reaction apparently so simple should prove so fruitful a field for research is surprising. The product first obtained was not silicon, as might, perhaps, have been expected, but its carbide. Furthermore, not one carbide, but two, appeared, the one a crystalline body of extreme hardness—carborundum—and the other amorphous and differing sharply from the first in certain of its chemical relations. Next in order it was noted that these carbides were not final, but intermediate products, and that a still higher temperature broke them down, volatilizing the silicon and leaving the carbon in the form of graphite: thus a second and most fruitful field was opened. Under proper conditions, however, it soon appeared that elemental silicon might, indeed, result from the reduction; and so the third page was turned.

From a new patent granted to Mr. E. G. Acheson and discussed in this issue's Analysis of Current Electrochemical United States Patents, it appears that a fourth product, "siloxicon," is to be added to the list—a compound, or, perhaps, a series of compounds, containing all three of the elements in the reacting bodies, possessing most unexpected properties, and resulting from a partial reduction occurring at temperatures which, comparatively speaking, are moderate. It would be hard to find a more striking illustration of the value of the intimate study of apparently simple reactions.

TANKS.

The tank which contains the electrolyte is one of the most important pieces of apparatus in the whole range of electrochemical engineering. This may appear to be a somewhat exaggerated statement to the theorist, but every electrochemical engineer who is responsible for the satisfactory operation of an electrochemical process on a large scale, knows the difficulties and troubles involved in devising a tank which will stand the test of time. It is at once evident that there cannot be such a thing as a tank of universal applicability, suitable for any and every electrochemical process. A tank is suitable for a special electrochemical process if it is absolutely inert in the various reactions which take place during the process. Pottery ware, metal tanks, especially of iron and lead, wooden, slate, concrete tanks, etc., all of them are satisfactory for special processes, and it is the duty of the electrochemical engineer—and often not the easiest and simplest duty—to find the most satisfactory and, at the same time, cheapest material for his special purpose.

For the electrolysis of chloride solutions slate tanks have been employed to quite a large extent, and their use will certainly be continued and will even increase in future. As long as slate is free from mineral veins, there is almost no action on it by chlorine and alkalies. In an excellent article, published in this issue, Mr. David H. Browne, the chief chemist of the Canadian Copper Co., advocates the use of concrete tanks for the same purpose, and describes in detail how to construct such tanks. In view of the fact that Mr. Browne has had an extended experience of many years with the industrial treatment of chloride solutions, this article will certainly be studied with great interest by our readers. It may sound somewhat paradoxical, but it is nevertheless true, that it is easier to write down and integrate the general differential equations governing the migration of the ions in the electrolysis of chlorides, than to build a cheap tank in which the process may be carried on industrially. We must be thankful to the electrochemical engineer who describes how to do such things.

ACETYLENE DISSOLVED IN ACETONE.

In this issue we publish a short but very interesting article by Mr. R. S. Hutton, the well-known director of the electrochemical department of Owens' College, Manchester, on a new method of storing acetylene, for which the important claim of absolute safety is made. According to Mr. Hutton, much use is already being made of this method in France, and an English company is preparing to use it extensively. We may add that the same method has also aroused considerable interest in this country for some time. The method is based upon two principles: First, the experimental fact that acetone dissolves a large amount of acetylene and that this mixture has no explosive properties; second, the use of porous material to fill up the whole space of the cylinders in which the gas is stored. This latter device is the new feature of the method, and has been suggested on account of the fact that the solution of acetylene in acetone is accompanied by a considerable increase of the volume, so that when acetylene is drawn from a cylinder in which this solution is stored, the volume of the solution would decrease and the free space thus formed would be occupied by acetylene gas, which would result in the danger of an explosion. To avoid this the use of porous material has been suggested.

This method of storing acetylene is entirely analogous to the storage of compressed oxygen and hydrogen in cylinders, which is now largely in use. The advantages of this method of storing acetylene over the direct generation from carbide are also evident and well pointed out by Mr. Hutton. On the other hand, it cannot be denied that this is a rather roundabout way of using acetylene. The cost of the cylinders and the acetone, the cost of storing and the freight charges will always be considered unnecessary expense, and the ideal at which the electrochemical engineer will continue to aim will always be the design of a simple, cheap and absolutely safe generator of acetylene directly from carbide. It is similar

with the use of compressed oxygen and hydrogen gases in cylinders. They will be used wherever small quantities are needed at a certain place, but if oxygen and hydrogen are needed in considerable quantities at one and the same place, it will be cheaper not to buy the compressed gases, but to install an electrolytic water decomposition plant. With acetylene the conditions are analogous, and for acetylene lighting installations it will always be preferable to use generators for the direct production of acetylene from calcium carbide. However, until the ideal method for this purpose has been found, the method of storing acetylene in acetone will render very valuable service, and we hope with Mr. Hutton that the influence of this method on the carbide industry will be of the most satisfactory nature in opening up many new uses for acetylene gas.

"OXYGEN-LIFT" STORAGE BATTERIES.

In the Synopsis of last month we printed an abstract of an article in a Swedish contemporary which claims priority for a Swedish chemist, Mr. Jungner, over Mr. Edison in the invention of the celebrated nickel-iron battery. Without wishing at present to discuss this claim, we may record the fact, which does not seem to be generally known, that the general idea of an "oxygen-lift" cell—*i. e.*, of a storage battery in which the electrochemical action consists in the transfer (or "lifting") of oxygen from one plate to the other—is as old as the storage battery itself. When the lead storage battery was invented, involving lead peroxide and lead as the two electrodes in the charged condition, it was thought that during discharge they were changed into lead oxide; the use of sulphuric acid was thought to be necessary only for increasing the conductivity of the electrolyte. We now know that the function of the sulphuric acid is entirely different, and that the lead cell is not an oxygen-lift cell. This is one of the many instances of a general, though vague idea of an invention existing long before the real invention was made, or before it was reduced to practice. Of course, such references to prior vague ideas should not have undue weight in deciding who should have the real credit for having accomplished something useful and practical.

INSULATING VARNISH FOR ELECTRIC MACHINERY.

In this issue we publish a very interesting paper by Mr. C. E. Farrington on defective machine insulation. The subject is of the utmost importance for the electrical engineer who has to construct his dynamos and motors in such a strong and durable manner that they will fulfill their duty even under severe conditions. As Mr. Farrington says, the designer of a motor never can tell which one of his machines will be located in the hottest corner of a rolling mill or may have to stand some day an emergency load in ordinary practice. The design of electric machinery, based upon most exact mathematical theory, has attained in recent years such a degree of perfection that it is safe to say that the weakest points of up-to-date electrical machinery are due to defects of the materials used. The insulating varnish may appear, at first sight, a small detail, but it becomes a matter of considerable importance in view of the undeniable fact that a great many electrical machines are crippled in practice on account of the use of defective insulation.

It is not difficult to understand this condition of things. Electrical designers are always excellent mathematicians and mechanical and electrical engineers, but generally no chemists. The problem of devising a good insulating varnish, however, is a chemical problem. We note with pleasure that among the papers to be read at the New York meeting of the American Electrochemical Society there is one by Dr. M. von Recklinghausen on insulating materials, a field for chemists. On account of its enormous importance for the electric fraternity, this is indeed a field which will be found to be quite lucrative to the chemist who solves the problems involved in this matter.

Speculative minds have asked why one should look for insulating materials, insulating varnishes and paints and the like, as it would be much simpler to cover the copper wire directly with some metallic cover of perfect insulating properties. This is of course only a very vague suggestion and without any value for the practice as long as this coating is not clearly defined. Nevertheless, it is not an absolutely impossible thing, and if a copper compound could be found which has the necessary mechanical, chemical and electrical properties, and which could be easily formed in a thin continuous layer on the surface of copper wire, this would certainly represent the ideal insulation. To quote an analogous, although quite different case, we may refer to the recent brilliant invention of Mr. Acheson, who covers the electric furnace carbon with a sheath of carbide, which is, at the same time, stable at the highest temperature and a good conductor of heat, and thus makes the production of pure metals possible in the electric furnace, while it had been impossible before on account of reactions taking place between the reduced metals and the carbon of the core. But it is useless at present to speculate about possibilities of insulating copper wire with a sheath of insulating copper compound which has, at the same time, all the other required mechanical and chemical properties.

The actual situation is clearly pointed out in Mr. Farrington's article. The copper wire, used in practice, is covered with cotton and an insulating varnish or paint is used for the sole purpose of making constant the initial insulation resistance of the cotton covering. It is therefore important to study the weaknesses of the cotton covering in order to correct them. Mr. Farrington discusses the principal defects of the cotton covering in detail, and, starting from these fundamental facts, he describes in a very interesting manner the long series of tests, extending over a number of years, to find the best constitution of an insulating varnish for general electrical practice. While it is to be regretted that, for commercial reasons, Mr. Farrington does not describe exactly the constitution and manufacture of his insulating compound, the paper is none the less interesting in view of the clear explanation of the reasons why certain materials should *not* be used in an insulating varnish.

NEW YORK MEETING OF THE AMERICAN ELECTROCHEMICAL SOCIETY.

In our last issue we printed the programme of the coming New York meeting of the American Electrochemical Society. As in the meanwhile this programme has been extended or changed in some particulars, we give here again the full programme for the convenience of our readers.

Members and guests will please register at the *Chemists' Club*, 108 West Fifty-fifth street, and receive their badges as soon after their arrival as possible. Badges will be given to all members in good standing and to applicants who have deposited their initiation fee. Special badges will be provided for guests, who must be introduced by a member. All meetings will be held in the large assembly hall of the Chemists' Club, where members in attendance may have their mail addressed, and where all announcements will be made. By the courtesy of the Chemists' Club, its club house, including the library of the American Chemical Society, will be open for the use of members and visitors.

The hotel headquarters of the Society during the meeting will be at *The Wellington*, Seventh avenue and Fifty-fifth street, half a block from the Chemists' Club.

By the courtesy of the *German Liederkranz*, its club house, 111 to 119 East Fifty-eighth street, will also be open to members and guests during the convention. Membership buttons will secure admittance.

On Thursday morning, April 16th, at 9 A. M., a meeting of the Board of Directors will be held, which will be followed, at 10 A. M., by the business meeting of the Society, at which reports of directors and officers will be presented.

Reading and discussion of the following papers: Wilder D. Bancroft, Ph.D., "Constant Voltage and Constant Current Separations;" H. T. Barnes, Ph.D., "Experimental Study of Some Electrode Effects;" J. W. Richards, Ph.D., and W. S. Landis, "The Electrolysis of Water;" Wilder D. Bancroft, Ph.D., "Experiments with Metallic Diaphragms;" C. J. Reed, "Protective Action of Zinc Chloride on Metallic Iron."

At 1 P. M. luncheon will be served at the Chemists' Club, by invitation of the New York members. At 2.30 P. M. reading and discussion of the following papers: Max von Recklinghausen, Ph.D., "Insulating Materials—A Field for Chemists;" H. B. Coho, "A Historical Review of the Storage Battery," with illustrations; Elmer A. Sperry, "The Use of Pyroxyline in Electric Storage Batteries;" W. H. Walker, Ph.D., "The Concentration Changes in the Electrolysis of Brine;" J. W. Walker, Ph.D., "The Influence of Some Impurities in Salt Upon the Yield of Soda by the Amalgam Process;" A. A. Knudson, "The Corrosion of Metals by Electrolysis;" Titus Ulke, "Modern Electrolytic Copper Refining;" N. S. Keith, Ph. D., "A Note on the Composition of Electroplating Solutions;" C. W. Volney, Ph.D., "The Formation of Nitric Acid Under Electric Influences."

At 7 P. M., reception of members and guests in the club-house parlors of the German Liederkranz, 111-119 East Fifty-eighth street. At 8 P. M., subscription banquet for members and guests. Ladies are especially invited to participate. The price per cover is $5. A fine musical programme has been arranged.

Friday morning, April 17th, 9.30 A. M., announcement of the results of the election of officers for 1903. Reading and discussion of the following papers: W. D. Bancroft, Ph.D., "Note on Electrical Endosmose;" Louis A. Parsons, Ph.D., "Ions and Electrons;" Carl Hering, "Uniformity in Electrochemical Equivalent;" W. D. Bancroft, Ph.D., "The Electromotive Force of Alloys;" Prof. C. F. Burgess and Carl Hambuechen, Ph.D., "Electrolytic Production of Metallic Compounds;" J. G. Zimmermann, "The Electrodeposition of Metals Upon a Rotating Cathode."

At 1 P. M. luncheon will be served at the Chemists' Club, by invitation of the New York members.

At 2 P. M., excursions to plants and places of interest, as arranged by the Excursion Committee, starting from the Chemists' Club. Three parties are scheduled for this afternoon, each one starting at 2 P. M. The first party visits the Willyoung & Gibson Co. and the works of the Crocker-Wheeler Co., at Ampere, N. J.; the second, the works of the Sawyer-Man Electric Co., the special exhibition at the store of Eimer & Amend and the Cooper Union Institute; the third, the plant of the United States Electrogalvanizing Co. in Brooklyn and the Brooklyn Navy Yard.

At 8.30 P. M. the Society will, by special invitation, be the guests of the American Institute of Electrical Engineers at their extra meeting, held in the assembly hall of the Chemists' Club, at which the programme is as follows: President Scott, "Introduction;" W. J. Hammer, "Radium and Other Radioactive Substances, and Certain Phosphorescent and Fluorescent Substances," "The Properties and Applications of Selerium," "The Treatment of Disease by Ultraviolet Rays."

On Saturday morning, April 18th, 9.30 o'clock, the following papers will be read and discussed: A. B. Marvin, "Electrolytic Conduction Without Electrodes;" P. G. Salom, "A New Type of Electrolytic Cell;" H. E. Patten and W. R. Alott, "Potentials of Zinc in Aqueous Solutions;" Woolsey McA. Johnson, "Notes on Electrolytic Depositions of Nickel;" Alfred H. Cowles, "What is the Capacity of Molecules for Electric Charge in Electrolysis?" B. McNutt, "An Electric Laboratory Furnace;" J. A. Steinmetz, "Exhibit of Aluminium Corrosion;" August Eimer, "Exhibit of New Apparatus."

At 1 P. M. luncheon will be served at the Chemists' Club, by invitation of the New York members.

At 2 P. M. excursions will be undertaken to plants and places of interest, as arranged by the Excursion Committee, starting from the Chemists' Club. Two parties are scheduled for this afternoon, the first visiting the New York Edison Station at Thirty-eighth street and East River, the Seventy-fourth street power house of the Manhattan Railway Co., the Ninety-sixth street power house of the Metropolitan Street Railway Co. and Columbia College; the second party visiting the Rapid Transit Tunnel and Columbia College.

At 8.30 P. M., meeting in the Chemists' Club, Assembly Hall. Presidential address by President J. W. Richards, Ph.D.; Max Von Recklinghausen, Ph.D., demonstration of the Cooper-Hewitt lamp and rectifier.

At 10 P. M. a German-American smoker (Kneipe) will be held at the Chemists' Club, Assembly Hall, buffet, luncheon, refreshments by courtesy of the New York members. A jolly social evening is assured.

Transportation will be on the certificate plan. All members not residing in New York City should secure certificates when purchasing tickets, in order to get return at one-third rate.

The local committee consists of the following members: Dr. C. A. Doremus, chairman; Alvis von Isakovics, secretary; W. S. Cameron, assistant secretary; G. C. Adams, C. Batchelor, C. S. Bradley, Wm. Hand Browne, Jr., Dr. C. F. Chandler, E. A. Colby, Dr. F. B. Crocker, Dr. G. Drobegg, R. A. Fliess, Dr. H. Foersterling, J. C. Hatzel, Dr. N. S. Keith, E. C. Klipstein, A. A. Knudson, Dr. Morris Loeb, W. N. McCoy, C. O. Mailloux, A. Monell, E. H. Mullin, H. N. Potter, Dr. M. von Recklinghausen, E. E. Ries, Dr. S. Sheldon, N. Tesla, W. D. Weaver, E. Weston, C. E. Whitney and Dr. F. G. Wiechmann.

The above elaborate programme shows that the local committee has spared no efforts to insure a full success of the meeting. The attendance promises to be even greater than at the Philadelphia and Niagara Falls meetings.

As we already noticed in our last issue Dr. Walter Nernst, the distinguished professor of electrochemistry at the University of Goettingen and inventor of the Nernst lamp, will be present at the convention.

CONCRETE TANKS.

By David H. Browne.

In the electrolysis of chloride solutions it is impossible to use lead-lined baths on account of the rapidity with which this metal is attacked both by soda and by chlorine. Wooden vessels are exceedingly awkward—the chlorides appearing to cause shrinkage of the fibers, in which result the hoops or bolts are readily corroded. Slate tanks are satisfactory, but are very expensive and require the utmost care in leveling up and in drawing together. As concrete has been found an efficient substitute for slate, some notes on the manufacture of concrete baths may be of interest.

The first requisite is a good, slow-setting cement. Slowness of set is necessary because in building large tanks it requires ten or twelve hours or even more to carry up the walls to the required height, and as the ramming must be continuous throughout this entire line, it is evident that if the bottom took its initial set before the sides were completed it would be injured by the vibration. The cement, therefore, should take longer to set than the tank to complete. Cheap cement is worse than useless. Saylor's cement has proved a reliable article, but any brand which will stand the "pat" test will be satisfactory.

The "pat" test is made by mixing a handful with water to a stiff paste and working the same on a glass plate into a cake about half an inch high and 3 or 4 inches in diameter. The surface should be troweled smooth and the sides brought down to a thin edge. This is allowed to stand a few hours, then is covered with a wet cloth and set aside in a cool place over night. If it sets slowly and shows no cracks on the surface or at the edges it will answer.

For the best work crushed granite should be used. This has a rough granular fracture or "bite," into which the sand and cement lock better than with any other rock. As the stone used is the weakest part, and as a good concrete, when broken, shows fracture across, and not around the particles of stone, it is important to use the best rock available. Failing granite, a trap rock or blue diorite is a good substitute. The size of the rock depends on the thickness of the walls; a safe rule being that no piece should be over one-quarter the thickness of the wall in which it is used. For ordinary tanks material passing through a screen of 1½ inches, and over a screen of ½ inch is satisfactory. The material smaller than ½ inch should be rejected, as it interferes with the filling of the voids.

The solidity of concrete depends largely on the care with which these voids are filled. To determine the void space, take a pail of crushed rock, calculate the volume and find the weight. Add now water till the pail is full and weigh again. Calculate the volume of the water and simple proportion shows the empty space between the particles of rock. This space must be filled with sand, of which in turn the voids must be filled with cement. The voids of cement are in their turn filled by the water absorbed. Hence for strong concrete the common use of the formula, "4 parts rock, 2 parts sand, 1 part cement." For less careful work a larger proportion of rock is often used.

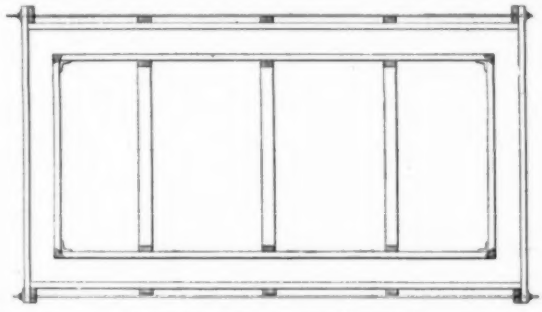
To mix the cement a tight mortar box or floor and a measure holding one cubic foot are needed. The rock should be thoroughly washed, and the sand screened from clay or gravel. One cubic foot of cement to two of sand is mixed on the dry floor to an even composition, and to this four cubic feet of stone are added, and the mass thoroughly shoveled over. Water is now added, so that, while no muddiness is apparent, each particle is moist. The mass is again shoveled over and is now ready for the mold.

This mold may be of any shape whatever. It is set on a solid floor, with a sheet of building paper underneath so that the tank does not bind to the floor. The sketch shows a form for a commercial-plating bath. The outer frame is trued at right angles and braced by struts to the floor to prevent bulging of the sides under the rammer. The concrete is now shoveled in, a few inches at a time, and thoroughly rammed until water shows at the surface. For a tank of the size shown three men are needed ramming and two men mixing and handling concrete. The tools needed are iron rammers, about 2 inches thick and 3 or 4 inches square, with a sleeve for a wooden handle. Such a tool, handled with a short, stiff blow, is better than a lighter tool, with a springy blow, the idea being simply to drive out the air from between the particles and completely fill the voids.

As soon as the bottom is of the desired thickness the inner frame is put in place and braced by cross pieces to prevent inward bulging. The sides are now rammed up, a few inches at a time. It is not desirable to lay the sides in layers, but rather to carry them up without coursing or stratification. One thing is very important, that there be no stoppages. If a meal time intervenes the men should be relieved one at a time, so that no pause occurs till the tank is completed.

The top finish is put on by bringing the concrete to within a quarter of an inch from the top of the mold and carrying this up with equal parts sand and cement troweled to a smooth surface. Any openings or holes in the tank wall are made by inserting a block of wood of the desired size in the side walls. After the tank is set the wood can be drilled or broken out.

Three or four days should elapse before the moldboards are taken down. The inner frame is removed by unscrewing the angle irons shown, when the side boards will drop inward without any difficulty. The outer form falls apart on removal



FRAME WORK FOR A CONCRETE TANK.

of the tee rods. If necessary the inner surface can be finished with a coat of sand and cement, but if planed boards were used for the molds the surface is usually quite smooth.

Concrete will not stand strong acids; caustic or chlorine has no effect upon it. A coating of paraffine or tar would help it to resist acids. It should not be subjected to sudden changes of temperature. If the heat be brought up gradually it will stand fire. It can be handled or lifted like a block of granite if ordinary care be used to prevent the tools from bearing against the sharp edges of the tank.

A tank with 6-inch bottom and 4-inch sides, containing 24 cubic feet of concrete, can be set up and completed by five men in one day. The cost decreases with the number of tanks built at one time and the facilities for handling concrete. Building four tanks of this size per day the cost per tank was as follows:

Carpenter and blacksmith labor on molds.....	$1.75
Concrete work labor, 30 hours @ 17½c.....	5.20
3.5 cubic feet cement @ 60c.....	2.10
7 cubic feet sand.....	.25
14 cubic feet crushed trap rock.....	3.00
	$12.30

Including finishing, taking down molds, cementing in rubber-pipe connections, about $15 will cover the cost of building a tank as above described, the dimensions of which are about 3 feet wide, 9 feet long and 2 feet deep. No construction of lead, slate or wood can be made which will fulfill all the requirements of the case for this sum.

ACETYLENE DISSOLVED IN ACETONE.

By R. S. Hutton.

Already, in 1896, Claude and Hess, in France, suggested the idea of making use of the solubility of acetylene in certain liquids as a means of storing this valuable gas. It is, however, only recently that any commercial use has been made of such a process, and much credit is due to M. Fouché, the director of the "*Cie francaise de l'Acétylène Dissous,*" and his colleagues for the perfection of the many details necessary to make a technical application at all possible. In view of the fact that already much use is being made of this process in France, and that the Acetylene Illuminating Co., in England, is preparing to employ it extensively in a somewhat modified form, it may be of interest to give a general description of the present condition of this industry and some of its applications.

Amongst a large number of liquids which were found to dissolve acetylene very readily, acetone was chosen on account of its comparatively high boiling point (56°C), and of its occurrence as a common industrial product. Acetone was found to dissolve 24 times its volume of acetylene at 15°C at ordinary atmospheric pressure, and as the pressure increases the solubility also very considerably augments.

Careful experiments were carried out by Berthelot & Vielle, amongst others which showed that the solution in acetone possesses none of the dangerous explosive properties which, it will be remembered, have been ascribed to the liquefied gas. It was thus proved that the solution could be safely transported under pressure in steel cylinders similar to those used for liquefied or compressed gases. However, since the volume of the acetone increases very largely by dissolving the acetylene in it, it follows that the cylinders cannot be completely filled with the mixture, but that a space must always be left, which, of course, would be occupied by the acetylene gas at a pressure corresponding to that at which it was held in solution.

Although comparatively little danger was anticipated owing to the small volume of the free gas, and to the fact that pressures above 10 atmospheres were not to be employed, the suggestion of making use of porous materials, to fill up the whole of the space in the cylinders and to absorb the solution was warmly welcomed. The great promise of the method depends largely upon the success of this modification.

Porous bricks and specially-prepared cements have been used, possessing a low density, 0.3 to 0.5, and considerable porosity, up to 80 per cent., and these are found capable of storing the solution of the gas under pressure up to 35 atmospheres without the least fear of explosion; but such high pressures as this are not even approached in the apparatus used for commercial purposes. The cylinders employed by the French company have a capacity of 2, 12 and 100 litres, and the volume of gas stored is 10 times their volume per atmospheric pressure, and thus about 100 times their volume at the pressure of 10 atmospheres which is normally employed.

At the factory the acetylene, prepared in a properly-constructed generator and carefully dried, is compressed in a pump, the two cylinders of which, quite separate from each other, raise its pressure to 3½ and 12 atmospheres, respectively.

At this pressure it passes directly into large storage cylinders full of porous bricks saturated with acetone. The cylinders which are supplied to the public contain similar bricks and are filled from these storage vessels.

The use of acetylene in this form obviates many of the troubles adherent to the direct generation from carbide; but, of course, necessitates the use of suitable reducing valves to insure a constant pressure of gas from the charged cylinders. The loss of acetone is comparatively small, only amounting to a few per cent. in each discharge.

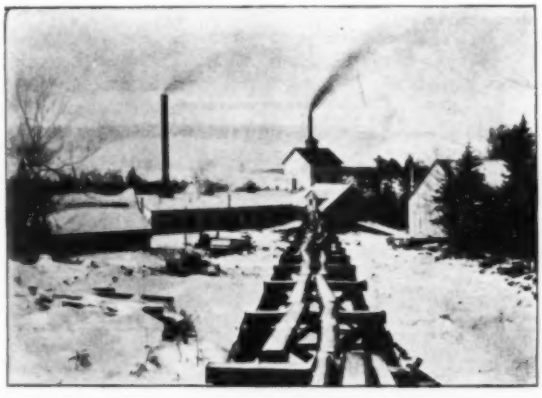
The applications so far made have been chiefly to the lighting of tramways, railways, and for similar purposes in which field the acetylene industry has not generally been very successful up to the present time. Much success has also been achieved by the same company with an oxy-acetylene blowpipe which has found extensive application in the welding of iron, steel and other metals. The gases are mixed in the burner in the proportions, 1 of acetylene to 1.8 of oxygen, and in order to get the velocity necessary to prevent the flame striking back, the gases are fed in under a pressure of 4 meters of water, which is, of course, easily accomplished from the cylinders of dissolved acetylene. The temperature of this oxy-acetylene blowpipe is exceedingly high, being capable of easily fusing lime, alumina, silica, etc. By regulating the proportions of the two gases either an oxidizing or a reducing flame can be obtained, but for the welding of the metals it is of course advisable to have as neutral a flame as possible by employing the gases in the proportions given above.

The further applications of this ingenious method will be followed with interest, and its influence on the carbide industry should be of the most satisfactory nature as opening up many new uses for acetylene gas.

THE PLANT AND PROCESS OF THE INTERCOLONIAL COPPER CO.

By Woolsey McA. Johnson.

The process of the Intercolonial Copper Co. for the electrolytic coining of copper presents several features of interest to electrochemists. Numerous attempts have been made in the past to produce electrolytic copper from a copper solution by leaching ore and electrolyzing against an insoluble anode. These processes have as yet met with but little success in competition with the old processes of mechanical concentration and smelting, of chlorination roasting and cementation on scrap iron, or of direct smelting, etc., several difficulties have arisen such as when sulphuric acid is used as solvent, its destruction by the lime and magnesia in the calcined ore,



REDUCTION WORKS OF INTERCOLONIAL COPPER CO.

etc. The solution must be regenerated with new acid at considerable expense. Power, coal, acid, labor and electrical machinery are expensive at remote mining centres and change economic conditions.

The insoluble anode has also been a hard question to solve. Platinum is too expensive and will lose weight with time, carbon is useless in a sulphate solution. Even the best Acheson graphite electrodes disintegrated as anodes in a sulphate solution and in almost all leaching proposition we have sulphate solutions. Lead gives the well-known "Casparische Ueberspannung" and will wear out from peroxidation just as the storage-battery positive will age with time.

How these electrometallurgical and commercial problems have been met will be found in the following account of the plant of the Intercolonial Copper Co. at Dorchester, N. B., Canada, which I inspected in January, 1903. This plant has

produced one ton of electrolytic copper daily for six or seven months, and has sold this to Canadian brass founders as equal to the best brands of electrolytic copper. Careful analysis of the cost sheet of this large experimental plant by the company's officials have convinced them that electrolytic copper can be had down at tidewater for 6 cents a pound. The working of the plant in the past year has unquestionably brought the process beyond the experimental stage. The only criterion of the successful working of any radically new process is the production of the article in large enough quantities to be sold in market. This has been done in the past year and the process has been subjected to a large scale test.

The ore of the Dorchester mines consists of a chalcocite weathered to the green carbonate or oxide. The copper is found in a vast lenticular mass in conglomerate and sandstone beds belonging to the carboniferous age. The copper ore is often associated with the fossil remains of this age and is found replacing the fossils. Large masses are found, but usually the copper in ore will run from 2 to 4 per cent. About $200,000 has been spent in blocking out ore, and the company's experts claim to have 78,000,000 tons of 3 per cent. ore in sight. This claim may be right, but the geology of the copper ore is so inconstant, as to make it uncertain.

This ore would be a difficult proposition to smelt, for it does not carry enough sulphur to render direct matting practicable, nor could such low-grade ore be smelted to black copper at present prices of coke and copper. Besides the ore is too silicious for furnace work. In both cases, very foul slays would result. "Weathered" chalcocite is a hard mineral to concentrate by water and large losses in tailings would ensue.

The ore could be treated by the "Henderson" process with undoubted success if a small amount of pyritic ore could be purchased, but it is doubtful if it could do better than the present process. The very small values in precious metals are

FACE OF TUNNEL, SHOWING COPPER-BEARING SEAMS.

lost by both these processes. I believe that the Henderson process has been worked with crude $NaHSO_4$ with good success, and this process could be made practical in this way.

Dr. N. S. Keith has a process to reduce at low red heat the copper in a carbonate or roasted ore. He mixes the ore with a small percentage of powdered coke and reduces it to small particles of metallic copper in a "Chase" roaster. The particles of metallic copper are separated easily by reason of high density by some mechanical concentrator.

Neil's SO_2 process is being worked successfully in Arizona. This, as is well known, consists in dissolving the copper in a solution containing an excess of SO_2 and precipitating it by boiling out this excess.

The Carmichael process meets the commercial conditions better than any of these for the following reasons:

1. Low lime.

2. Cheap coal, $3.65 per ton at firebox, as the plant is 4 miles from tidewater, near Nova Scotia coal mines.

3. Cheap mining.

The ore from the stopes is mined into chutes, wherever possible. These chutes lead to ore bins which empty directly into small tramcars. The cars run by gravity down the inclined tunnel and dump automatically into the ore bins before the

BATTERY OF CARMICHAEL ROASTERS.

crusher. The situation of the mine on top of hill renders tunneling practical. The ore is crushed in a Buchannan crusher and then carried by elevator to screens. The coarse from the screens goes to reducing rolls, thence back to screens, repeating the operation until the ore is 20-mesh fine. From the screens the fine ore drops to large ore bins. From the ore bins it is fed by screw conveyors into a battery of 15 Carmichael roasters. These consist of long tubes of cast iron passing through a fire-brick muffle, heated by a flame from the fire box. The first part of a roaster is a brick-lined drum. All revolve, and the ore is first partially desulphurized in brick drums. The ore next passes to the iron tube where it is dead roasted. Any lime is now sulphated and the iron is changed to the ferric state. The roasted ore from the revolving drums is carried by a chain conveyor directly to lead-lined bricked vats of 20 tons capacity.

These roasters are efficient but are liable to break down, of small capacity, and a furnace man would say, cause too much "fuss and bother." Units turning out 2 to 3 tons are not in fashion in America now. The old White-Howell roaster is of similar design, but has been long given up. The ore could be more easily and cheaply roasted in a Brüeckner, or, if a continuous-working furnace was required, in the old-tried Brown, or the promising new roaster of Capt. Chase. There are other well-known roasters that could be used if necessary, such as Davis, Pearce turret, or even hand-raked reverberatory.

The hot ore falling from the conveyor drops into a 5 per cent. solution of H_2SO_4. The solution of the copper takes place rapidly. This is an old and well-tried reaction that works well on a large scale. The "made solution" carrying 2.5 per cent. Cu and considerable free acid is drawn off to the "storage" vat. The fact that there is left in the solution this free acid, makes a 95 to 98 per cent. extraction a practical proposition. The tailings assay lower than 0.10 per cent. Cu. This is a strong point of the process, as the solution of the copper is slow when the copper grows high and the acid grows low.

The solution is drawn off, pumped to storage vat and impregnated with SO_2 gas (made by burning brimstone in an

iron pot under blast) in the storage vat. The electrolyte runs down from the storage vat to the plating vats which are arranged in cascade. Sulphur dioxide is also blown through the electrolyte in vats by means of perforated hard-rubber tubes. This bubbling of the SO_2 is desirable for the following reasons:

1. It makes good "top-bottom" circulation.

2. It protects lead anodes from peroxidation. Sulphation will occur in time.

3. It adds H_2SO_4 replacing that used in neutralizing small amounts of CaO. Practically, the acid is made at a cost of $6 per ton H_2SO_4—100 per cent.

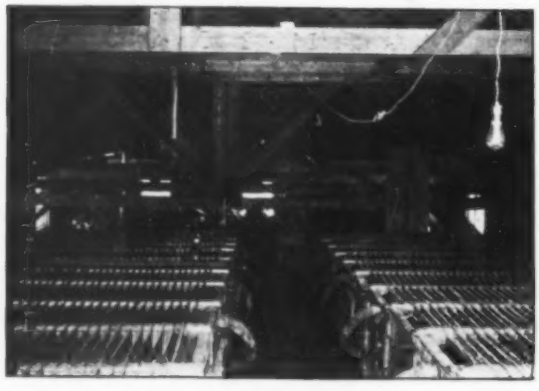
4. It acts as a depolarizer and reduces voltage of vats, and consequently amount of power necessary to deposit 1 ton of Cu.

This part of the process is old, in fact first patented in 1878 by an Englishman. It has been repatented several times in many countries, although it is quite doubtful if the Chinese or Fiji Island patents are valid. I worked out this electrochemical reaction independently some years ago, as follows:

$$4\,(+) + \overline{\overline{SO_2}} + \overline{\overline{O}} + H_2O = \overset{++}{H_2} + \overline{\overline{SO_4}} + 2\,(+)$$

where the + and — in paranthesis and the + and — over the chemical symbols represent ionic charges.

This reaction with lead or platinized platinum anodes proceeds in accordance with Faraday's law. As there is a union



ELECTROLYTIC ROOM.

of positive and negative charges, the free energy necessary for electrolysis is less than if no SO_2 were present. In other words the SO_2 acts as a depolarizer. My idea had been to use this for H_2SO_4 production in connection with an electrolytic refining plant which was proposed by my employer. This idea is, of course, also old. It is merely mentioned as one more illustration of the fact that different minds often produce the same solution of problems. The last man to re-invent this reaction is C. J. Tossizza, of Paris, who patented it in the United States, September 30, 1902.

The copper is precipitated at the Intercolonial plant at 1.5 volts, 6 ampères per square foot, electrodes of lead about 1½ inches apart. The current efficiency is about 90 per cent. The cathodes are greased and graphitized. The cost of power would be from $25 to $30 in the present small generating plant. This is more than cost of "cementing" on scrap iron, but the product is worth at least $30 per ton more than 80 per cent. "cement copper." Besides the solution is easier in this process, because the copper can be thrown down from acid solution, while in the "cementation" process free acid means just so much more iron used before the copper is thrown down.

Using wood at $1 a cord, or coal at $4 a ton in "Loomis-Pettibone" gas producers with Westinghouse gas engines to generate power, as is done by Phelps, Dodge & Co., in Mexico and Arizona, the cost would be much lower, probably as low as $8 to $9. Water-power might reduce the cost of power to $5 or even $2, as a low figure.

The electrolysis is conducted until the Cu content is reduced from 2.50 per cent. to 1.00 per cent. The solution regenerated in acid by anode and cathode reaction is not subjected to further electrolysis, but is used for leaching new ore. This is another skillful use of electrochemical knowledge, as the removal of the last 1 per cent. of Cu would be very expensive, because of decreased current efficiency.

The ore when leached is washed and sluiced by water from the mine which is on a higher level than the electrolytic plant.

This process is a good verification of the prophecy made by the English electrochemist, Mr. Bertram Blount, on page 88 of his "Practical Electrochemistry:" "That it (electrolytic winning of copper) will be achieved in the near future is probable enough. . . . What is wanted is not so much a totally new device as a well-schemed plant embodying perhaps nothing but what is common knowledge, but planned so as to be fairly permanent as a whole and with its perishable parts easily and cheaply renewable."

The estimate of the company is as follows:

Value of 57 pounds of copper at 12 cents per pound,		$6.84
Cost of mining and delivery to mill, per ton	$1.50	
Cost of milling, per ton	2.00	
		3.50
Net profit, per ton		$3.34

"These figures, based upon a comparatively small tonnage, bear out closely the early estimates of Prof. Carmichael on the cost of producing copper here, and are believed to be conservative. It is therefore apparent that the plant as at present constructed, running to its full capacity, will show substantial earnings on the capital stock issued, while it is obvious that the operation of a large plant treating 1,000 tons daily, for which the ore supply is believed by our engineers to be ample for a long term of years, will establish this enterprise as a great and permanent mining industry.

"The mining and development work of the company has been under the supervision of L. S. Griswold, M. E., of Boston. The process for treating the ore and the plant are the design of Prof. Henry Carmichael, of Boston."

If the plant and process do not develop into a commercial-paying proposition it will be in my opinion either because 3 per cent. ore cannot be found or because the lime and other soluble impurities increase to too high a figure, or because of unexpected financial trouble. The process is certainly well suited to treat ore of this character. Low copper, high lime, or lack of capital would of course cause a failure.

Output of Electrolytic Refineries.—Mr. Titus Ulke kindly informs us that since he sent us his article "Notes on the History of Electrolytic Copper Refining in America," published in our last issue, he has received subsequent returns from several refineries, which change somewhat the statistical figures given in his article. The corrected figures are as follows: The total daily copper output is 764 tons, or 279,000 tons per year. At the same time the amount of silver and gold recovered per year in the electrolytic copper refineries is 27,000,000 ounces of silver and 346,020 ounces of gold.

From reports of the Treasury Bureau of Statistics it appears that the copper exports of the United States consist chiefly of electrolytic copper. Their value was $33,534,899 in 1901, and $45,485,598 in 1902. The number of electrolytic copper-refining plants in the world, either now in active operation or ready to start operation, is 33, of which 10 are in the United States, 9 in Germany, 6 in Great Britain, 4 in France, 2 in Austria and 2 in Russia.

THE ELECTRIC REDUCTION OF IRON ORES AND THE CONVERSION OF IRON INTO STEEL IN AN ELECTRIC FURNACE.

BY LOUIS SIMPSON.

When Sir Henry Bessemer first brought his invention before the notice of the steel manufacturers of Great Britain, both he, and his invention, did not receive, at their hands, the attention and consideration that has since been proved the invention warranted.

It was only when enterprising capitalists advanced the money necessary to operate a works, wherein steel was manufactured under what is now known as the Bessemer process, that the steel makers of Great Britain began to investigate the process, and eventually applied for licenses for rights to manufacture.

History is ever repeating itself. It is not surprising that the steel makers of to-day have looked with scepticism upon all of the several processes now available, of electric reduction and conversion, although certain of those processes have reached practical development and are here to stay.

One cause of their want of interest is probably due to the fact that, in the past, the advocates of the electric furnace have not shown unanimity in advancing the best claims of this process and have at times claimed that which could not be sustained. They have too often so spoken and written as to raise doubts in the minds of practical steel manufacturers, even in some instances to the extent of "damning by faint praise." At the Niagara Falls meeting of the Electrochemical Society, Mr. Salom stated that in his opinion: "There is not much danger, in the immediate future, of the electric furnace superseding the blast furnace, as a method of manufacturing iron or steel, *although the possibilities of it are not to be ignored in the future.*" This remark would suggest the thought that whilst the steel manufacturer may for the present ignore the possibilities of the electric process, yet it would be well for him to give it attention, lest some fine morning he might wake up to find that, whilst resting in fancied security, some competitor had captured part of his business by the aid of the electrical process. Other speakers expressed the opinion that the electric furnace for iron and steel "has the very great handicap of high cost." The report published in THE ELECTROCHEMICAL INDUSTRY is herein quoted. It is, however, not clear whether the "high cost" referred to is intended to mean a supposed high cost of working or to a supposed high first cost of erecting a furnace.

Mr. E. R. Taylor, at the same meeting, claims that "he could now construct a continuous electric furnace that would dwarf the largest blast furnace in existence." Mr. Taylor has been very successful with his furnace, which he uses for the manufacture of carbon bi-sulphide, and there would seem to be no reason why the same furnace with modifications should not be used for the reduction of iron ores. But for the fact that Mr. Taylor's electrical plant is of insufficient capacity, his type of furnace, long ago, would have been tested as to its possibilities in the reduction of iron ores. In THE ELECTROCHEMICAL INDUSTRY'S issue of February, Mr. Marcus Ruthenburg claims that through a furnace of his invention "iron ore can be reduced at a cost of 500 kilowatt hours per ton."

Few of those who have written on this question have published statements that would appeal to the practical manufacturers, that is to say, those who have made it their business to know something about the cost of power production, of electricity and of steel making.

Some of these writers even lessen the value of their opinions upon the possibilities of the electric furnace, by making statements upon some side issue, which statements being obviously open to criticism, causes the reader to doubt the correctness of the opinions and data given in respect to the electric furnace.

The commercial practicability of the electric process is a question of such a complex character that it is difficult for an expert of any one of the several branches of science interested to form a correct judgment upon the question, as a whole; unless he is posted in all the other branches, and further, unless he has considerable knowledge of the commercial end of the question. It is not sufficient that this question should be considered by an electrochemist, nor by an hydraulic, civil, mechanical or electrical engineer; it is not sufficient that it should be considered by a metallurgist. It is necessary that the question should be considered by a man of experience in the market for which the steel made by the electric process is intended.

To illustrate this Mr. James Swinburne, president of the Institute of Electrical Engineers in Great Britain, in his presidential address given before that Institute, stated as his opinion that water-powers were of no great commercial value. The fact so stated may be and probably is correct, if applied to Great Britain, but is not correct when applied to the continent of North America, and especially to the Dominion of Canada. The causes given by Mr. Swinburne as being the basis for his statement are not existent at or around a considerable number of the waterfalls of this continent. Had Mr. Swinburne been an hydraulic engineer, had he the information, and had his experience in hydraulic propositions equalled his experience as an electrical engineer, he would either not have made such a statement or else he would have been careful to have limited its application to certain European countries.

It is not necessary to claim that the electric furnace will supplant the blast furnace or cause a revolution in the manufacture of steel. The blast furnace will probably be used under certain conditions. The electric furnace will certainly be used when and where other conditions exist. Amongst these conditions, the proximity of the consuming market to the electric furnace is of an importance too great to be ignored.

It is now admitted that the quality of steel made through the electric furnace is equal, and it is a question if it is not superior to the steel produced by any other known process. The question at interest is whether it is possible to manufacture steel using the electric furnace at a less cost, or at the same price as can be done by other methods. To the cost of producing steel must be added any extra freight, over and above the average, which may have to be paid for conveying the steel from the steel works to the different consuming markets.

Of course, the cost of carbon, in whatever form used, and of electrical power, if used in place of carbon, is a considerable factor. It cannot, however, be claimed as being the only factor worthy of consideration.

It is always difficult to compare the cost of producing manufactured materials or goods, when the conditions, under which they are manufactured, differ widely. There is difficulty in ascertaining the lowest cost of producing steel by the blast and open-hearth furnace process. Up to date, although numerous small works are producing steel of good quality by the electric process, no works have been erected of a magnitude sufficient or under such favorable natural and local conditions, as would insure the most economical production. It would, however, be no argument to assert that steel cannot be produced at a certain low figure, because under the conditions existing at and around these several small plants, steel by the electric process is not being produced at a cost as low as it can be produced elsewhere under different conditions.

Certain data have been secured from the results obtained at certain of these works, which have produced steel of excellent quality. This steel has not been produced under the most favorable conditions, such conditions as are known to exist upon this continent, more especially in the Dominion of Canada. This data corrected to conform with the conditions indicated will give the possible cost of producing steel by the electric furnace where conditions are favorable.

The charges which together make up the cost of steel are as follows:

1. Raw material, consisting of (*a*) iron ore (assembled).
   (*b*) Carbon (assembled), used to combine with the oxygen contained in the ores.
   Carbon (assembled), used for heating or electric power used for heat.
   (*c*) Limestone (assembled).
2. Labor.
3. Repairs, renewals, taxes, insurance and depreciation.

To which must be added any excess of freight charges which have to be paid by the customer above the lowest existent freight charges.

The lowest known cost of producing steel ingots per ton by the blast and open-hearth furnaces, have been stated to be as follows: It must, however, be remembered that the works were situated at a considerable distance from the chief consuming markets, therefore an unknown sum for excessive freight charges has to be added.

1. Iron ores (assembled)	$2.33	
Loss in iron from pig to steel	1.00	
		$3.33
Coke		3.77
Limestone		.30
2. Labor		2.50
3. Renewals, repairs, depreciation, etc.		2.00
Extra freight		uncertain
Cost of steel ingots at works, to which must be added cost of extra freight to consuming markets		$11.00

To-day the costs of iron ores, coke and labor have all advanced. At Pittsburg the cost of these items is considerably higher than quoted above, but the cost of excessive freight charges would in the latter case be unimportant. This question of excess in freight charges must always be borne in mind, but cannot be stated at any constant figure, it being ever a varying quantity.

Under conditions known to exist upon this Continent, more especially in the Dominion of Canada, the cost of iron ore and of limestone (assembled) as above stated may be considerably reduced, while the cost of labor is lower, as also the cost of repairs, renewals, depreciation, etc., when the electric furnace is used. For the local markets there would be a very considerable saving in the freight charges paid by the consumer. The total of these savings, in one case now under consideration would amount to over $3.50 per ton.

The lowest known cost of the carbon used in the blast and open-hearth furnaces, has been given as $3.77 per ton of steel ingots, this cost, however, cannot to-day be duplicated. The saving of $3.50 already indicated would permit the steel maker, when using the electric process, to expend upon the carbon, electric power and electrodes, the sum of $7.27 for each ton of steel ingots made, and yet the total cost would not exceed the lowest cost of production, under the blast and open-hearth furnace process.

According to data in the possession of the writer, steel ingots can be made by the electric furnace at a cost as low as $10.61 per ton, while the inventors of certain new electric furnaces, not yet tested practically, claim reductions in the cost of the process made in reducing the amount of electric power and of electrodes consumed, which, if correct would, in one case, amount to a reduction of $2.09 per ton, and in the other, to a reduction of 81 cents per ton, making the cost price $8.52 and $9.80 per ton, respectively.

There has always been great contention as to the cost of electric power. Calculations of cost have been based upon power costing $20 per horse-power year, because forsooth, that is the price charged by the power company at Niagara Other calculations have been based upon power at $15 per horse-power year, because another power company charges such an annual rental, while other calculations have been based upon the more reasonable rental of $10 per horse-power year, but for a reason no better than that possessed by those who used $20 per year, as a basis for their calculation. One expert condemns employing hydraulic power wherewith to generate electric power, and claims that electricity can be generated from the combustion of soft coal at a price that will put "water-power in the shade." This expert claims that 500 kilowatt hours can be produced by the combustion, *under a steam boiler*, of 1,000 pounds of soft coal.

It is unnecessary to point out that up to date it has been impossible, *under ordinary continuous working condition*, to produce 500 kilowatt hours by the consumption of 1,000 pounds of any kind or quality of coal, burned under any kind of steam boiler. Nor is the quantity of coal consumed by any means the sole expense in producing steam, by the combustion of coal. Wages, repairs, oil, depreciation, insurance, packing, etc., must be accounted for.

When a power company leases electric power at the rate of $10 per annum, such rental is not necessarily the cost of producing electric power. In most, if not in all of these power companies there is more water than that which flows or has gone over their water falls, and in any case the annual rental not only includes the cost of operating, of maintenance and of depreciation (the actual cost of the power), but also an amount necessary to provide for interest upon a large bond issue and further the dividends to be paid upon a large issue of stock, much of which is made necessary by the presence in their stock of the water, that never went over the falls.

Under favorable conditions electric power can be produced for less than $4 per electric horse-power per year.

There are certain important advantages which may be claimed for the electric process over the blast and open-hearth furnace process. They are as follows:

1. The steel produced is more compact, it is more regular in quality.

2. In the same works, and that of no great magnitude, different qualities of steel and of steel alloys can be produced and that at a minimum cost.

3. Providing power has already been developed the output of a works can be quickly increased. The works can be closed down without damage to its furnaces, and it can be restarted at a day's notice.

4. Up to the ingot, no skilled labor is required other than the electricians and metallurgists.

5. The cost of the developed power is balanced by the reduced cost of the furnaces.

6. Less loss in output.. No closing down of works because of repairs being required to the blast furnace. The cost of the electric furnace is so low that it permits of the erection of one or more extra furnaces, which can be quickly run into commission should any of the furnaces then in work require repairing.

It is claimed that by the electric furnace steel can be produced:

1st. Of a quality as good as, if not better than can be produced by the blast and open-hearth furnaces.

2d. There are no disadvantages connected with the electric process.

3d. There are several important advantages connected with the process.

4th. Given the existence of certain natural conditions, which will be indicated, the steel so made can be produced and delivered to certain markets at a price as cheap as, or cheaper than the steel produced by the blast and open-hearth process when delivered to the same market.

The natural conditions referred to, part or all of which should be present, are:

Low-priced iron ores of high grade and good quality.

Low-priced limestone.

Low-priced electric power, however generated.

A nearby consuming market.

DEFECTIVE MACHINE INSULATION.*

BY C. E. FARRINGTON.

The best excuse for a discourse on the defective insulation which is found in modern dynamo and motor construction is the statement that it is the greatest obstacle to electrical development at the present time. It is a fact beyond controversy that the electric motor is not being used as much as it would be if it were a more perfect machine. A veteran railway superintendent whose title was once "barn boss," recently told me how much he wished that he could have as little sickness in his motors as he used to have among the horses.

My connection with the manufacture of electrical insulation was brought about through the request of a large electrical manufacturing company for a substitute for shellac as an insulating varnish. This was some ten or twelve years ago, when all that any paint and varnish chemist knew about insulation was what he might derive from the examination of a dictionary, so we asked our electrical friends for full details of the work an insulating varnish had to do. The answer, signed by one of the best known of the large construction concerns of a dozen years ago, is in my possession to-day and reads: "An insulating varnish must contain as little water as possible and dry quickly. We cannot give you further details, but if you will make the varnish as above stated we will make the tests to see whether it has any insulating properities."

If such an answer had been rendered on any other point concerning mechanical or electrical engineering it would have been considered a glaring admission of ignorance and no large electric company would have tolerated such ignorance after it had once exposed itself. But it is a fact that electrical engineers have neglected to use the methods of applied chemistry in this most important item of their work. They have cheerfully gone on and on, jauntily ignoring well known chemical laws and trusting to the cleverness of their sales departments to shift to buyers the responsibility for losses and annoyances which might be wholly avoided were conscientious study made of the problem.

By our inquiry we finally ascertained that shellac varnish (gum lac dissolved in alcohol) gave the best results of anything which they had then used, but that electricians were quite well aware that it was defective. As no further information was forthcoming, we proceeded to make a very rapid drying copal varnish which was duly submitted to our electrical friends, and after a few days' test it was adopted by them and its use commenced in considerable quantity. It was the first insulating varnish ever made. As an illustration of what we have learned since then I will say that no competent engineer will now concede that a given compound has any insulation value whatever until his tests have been those of actual service under widely different conditions, and unless the time test is at least a year.

We submitted samples of our insulating varnish to several other electrical concerns and invariably received flattering testimonials as to the wonderful insulating properties which it possessed. We gave it the name "insullac," and I think during the next six months we unintentionally crippled as much machinery as we insulated. I think the record which we made at that time has been equaled once or twice since by some of our enterprising competitors. But in justice to them I must say that they were guided by just the same sort of advice as we had. The experience of that six months produced a profound impression. Savage complaints convinced us that the testimonials of our electrical friends were better testimony of their ignorance of the chemistry of insulation than of the quality of the material whose praises they sang. Our surprise and regret were superseded by an ambition to atone for our error, and we determined to learn something about the subjects for the benefit of those whose injury we had unwittingly assisted in.

It is my pleasure to outline here the course of study which was opened by this investigation. It was primarily necessary for us to define the exact function of a varnish in and on the coils or windings of a dynamo electric machine. Why should a varnish be used at all? Solely because there has never been an insulating fibre produced which did not need some sort of reinforcement which could obviously be best applied in the form of a paint or varnish. Motors will not run, even in very dry situations, unless some protection in the shape of varnish is applied. We asked electricians for an explanation of this they told us that water got into the machines if varnish was not used. When this answer was applied to street railway motors running on submerged tracks or on motors unprotected from street spattering, the explanation seemed to be adequate, but its adequacy was completely lost when we applied it to stationary machines running under fairly good conditions.

Surely the insulation resistance of the varnish is not required to enable the machine to run. There probably never has been a successful machine designed wherein the difference of potential between windings was equal to 10 per cent. of the insulation resistance of the ordinary double-cotton covering which was used on those windings. This covering has an insulation resistance standing about 200 volts a c, and it is obvious that if that resistance could be made constant there would be no necessity for the reinforcement of machine insulation with anything in the line of paint or varnish. In other words, any paint or varnish which is used on magnet coils is used in the hope of making constant the initial insulation resistance of the cotton covering.

It being plain that the function of any varnish or paint which is applied to a motor or dynamo coil is to reinforce the cotton covering we must study the weaknesses of the cotton in order that we may know how to correct or help them.

The first defect of cotton is the fact that it cannot be spun to a commercial profit unless it carries from 5 per cent. to 15 per cent. of water, but at the same time our attention should not lose the fact that this water does not interfere with the average insulation value of cotton covering as indicated by mere laboratory tests. The trouble which the water makes is accomplished when it turns to steam under the heat of the machine, or when it travels from the core out through the coil under the influence of rotary motion, leaving innumerable passages and openings where the electric current may follow.

Another material defect of cotton is the ease with which it becomes carbonized, but it is only fair to say that the carbonization of cotton covering is largely offset by the resistance gained from the expulsion of moisture as an armature becomes dried and seasoned.

The third defect of cotton is the acid which it carries and which assists its impregnation with copper oxide.

Determining that the best insulating material must be the one which would reinforce these weaknesses of cotton, we assembled all the materials commercially available for the manufacture of compounds which might be applied to coils of copper wire by dipping or with a painter's brush and began the work of systematic search for the qualities which would enable these materials to accomplish the necessary results. In this connection every varnish gum, every treatment of drying oils, every combination of waxes, pitches, asphalts and gum substitutes, including the cellulose compounds, were brought under our tests.

The first test of all was to see whether a material had a melting point or a viscosity or a combination of both which would enable it to stay in a badly overheated coil. This point brought out a curious inability on the part of a good many electricians to distinguish a difference between old-fashioned tests and modern conditions. They wanted to test insulation melting points by the same method by which oil chemists

* A paper read before the Franklin Institute of Philadelphia on March 12, 1903. Mr. Farrington is chief-engineer of the Massachusetts Chemical Co., of Boston.

find the melting point of an oil or a wax, but we found that test so misleading as to make it necessary to make our tests exactly like the conditions of actual service. We wound a coil of double cotton-covered wire about a steel rod, saturated the coil with insulating compound, withdrew the steel rod, inserted in its place an ordinary thermometer, put current through the coil via water resistance until the coil was so badly heated as to give off dense volumes of smoke, and if by weighing we found that a coil did not lose more than 10 per cent. of its compound we decided that such material would stand hot service in overloaded machines. An insulating compound should have such a high melting point. The designer of a motor never can tell which one of his machines will be located in the hottest corner of a rolling mill, or whether his generator may not some day have to stand the heat of a torpedo boat engine room with the ventilating apparatus broken down, or an emergency overload in ordinary practice.

The tests to determine the capacity of a given insulating material to exclude moisture from the coils of an idle machine were chiefly a process of elimination, and here we found aid from the experience of varnish and paint manufacturers, and in the researches which have been made concerning the materials which enter into their products.

We first eliminated shellac for the reason that it could only be made into a successful varnish by dissolving it in alcohol, or alcohol and water. You can make a shellac varnish totally devoid of water, but you cannot do it commercially, and if you could you could not keep it so, as the alcohol in shellac varnish rapidly attracts moisture the moment it is exposed or applied.

The copal varnishes and asphalt varnishes were eliminated at this point, as we found that the heat and vibration of magnet coils quickly reduced them to a powder or cracked their films so badly that they could not exclude water any more than a sieve could hold it.

For some time we thought that linseed oil might be so boiled that it would effectively exclude moisture. We were attracted by its high initial resistance and the extremely tough film which could be obtained from varnishes composed of it, but here again we were stopped by the accumulated facts which experienced varnish and paint makers furnished us. Linseed oil is a commercial commodity solely because of the rapidity, as compared with all other oils, with which it absorbs oxygen. A method of arresting the oxidation of a film of linseed oil at any desired point would be of immense value to the electrical fraternity. We cannot hope to arrest the oxidation of a film of linseed oil at any particular point. It continues to oxidize until it becomes a brittle, cracked and utterly defenceless mass, so far as its capacity to prevent the passage of any stray electric current is concerned. More electrical apparatus have been reconstructed or repaired because of the oxidation and other defects of linseed oil than of all other causes put together.

A great many electricians like to claim that their apparatus is well ventilated. "Well ventilated" also means well oxidized. There are very few armatures which are not well ozonized also.

When the wearer of a black coat leans against the white trimmings of a house which was painted with linseed oil and white lead last spring, he has to dust himself off, simply because the oil which should have held the pigment to the house has been totally destroyed by atmospheric action. It is because of this quality of linseed oil that we are compelled to have a varnishing day in our art galleries, and it has never been disputed that thoroughly oxidized linseed oil is not only soluble in water, but is hydroscopic, since that fact was established many years ago by eminent German authorities.

We had to consider that an insulating compound might be used some day in a generator located on top of a steel penstock in an isolated power house where there was no heat, and that when the generator should shut down it would attract moisture at a tremendous rate by condensation. It would not run a week under these conditions if it were insulated with a linseed oil preparation. It is well known that a series of chemical actions may take place in an electrical machine, wherein linseed oil may be found wholly responsible for the presence of water even before the oxidation of the oil has reached the advanced stage. This occurs when an atom of hydrogen in the oily acids of the varnish is replaced by an atom of copper. The ejected atom of hydrogen selects a pair of friends from the oxide on the wire and thus produces water. Only one material was able to pass these tests for the exclusion of moisture under practical conditions, that being the high melting point paraffin compound whose widely successful use has brought to me the honor of delivering this address.

A particular point which led us to the adoption of this material is its capacity to withstand high temperatures for a great length of time and still maintain its original plastic condition. The vibration in a high-speed armature probably equals that in any mechanical device when the shattering jars of gear connections are taken into consideration and when street railway machinery is added to the list of apparatus under consideration.

The expansion of armatures and field coils as they heat and their subsequent contraction when the loads are removed are obvious and consequently any insulation which does not have permanent plasticity under heat is wholly defective for this sort of electrical insulation. Consequently a large list of materials composed of varnish gums and linseed oil, asphalts, etc., were eliminated one by one as they showed their utter incapacity to stand the shattering influence of this vibratory stress.

The defectiveness of the first material which we ever made was caused wholly by the presence of varnish acid. As is well known to varnish chemicals, all of the varnish gums are acid bodies. Indeed, it is safe to say that there is practically nothing in the shape of gum or oil which enters into varnish that is not an acid body. The question then arose "How far is anybody warranted in introducing acid into the vitals of high-cost apparatus?" Of course the answer is, "Just as little as possible," but I am sorry to say that a good many electricians have declined to give this point the consideration to which it is entitled, and they have thereby become responsible for a great deal of the apparatus which has proven defective. Of course I am familiar with the claim of some electricians that they "never have any trouble with apparatus built by them." In the first place we know that such a statement is not true, and if it was true, it would not be a good reason for deliberately disobeying physical law.

From one end of this country to the other you can go in the street railway field and find apparatus which has gone to the scrap heap chiefly because it has been insulated with defective insulation. Within a year one of the largest generators in the world has had its armature twice rewound because it was insulated with defective insulation, and on the third trial its builders repaired it with the same stuff which first short-circuited it. The money loss in that instance is already close to $10,000, with more to follow. There is not a central station manager in the United States who has tried to sell power who has not come into contact with a manufacturer or a machine shop superintendent who told him he would not put in a motor unless the central station man would guarantee against his shut-down losses and against repairs. Printers have discarded electric motors for gas engines because they say the gas engines have a reliability which motors have not.

Every defective electric motor is an argument for the sale of an engine in its place, and it is only so because the motor manufacturers have neglected in their rush to keep up with commercial progress to give to their insulation the same care and thought which the engine builders have given to their construction. The same processes of elimination which keeps poor metal out of piston rods will keep poor insulation out of armature coils. But at present manufacturers will not seek

such improvement until consulting and operating engineers insist upon it.

The obvious unfitness of linseed oil for motor insulation, because of its acid composition, is best explained by reference to indisputable authority. What everybody knows "is most indisputable authority," and anybody who knows anything about chemistry knows that an acid is a body which will attack metal. An acid is a body which attacks copper. An acid is a body which will combine with copper to produce a third and possibly a fourth material. Users of shellac, copal varnish, and linseed oil varnish as insulation have frequently found that the cotton covering of their wire has been turned a brilliant green, which is a universal symptom that the copper has been attacked by an acid. When we said that such a symptom was a bad one some electricians argued with us and said they didn't think we had any authority for that statement and that it didn't make any difference if a coil did turn green, provided that coil was properly baked out. They declined to accept what every chemist knows. We have given considerable thought to this matter and have come to the conclusion that a green coil is an evidence of bad construction, is *prima facie* evidence that a radical chemical change has gone on within precincts whence chemical changes should be excluded with great rigor.

Green discoloration is evidence of inconstancy where constancy is indispensible. As it is very seldom seen except as a relic of a broken-down machine, it may therefore be said to be coincident with burned-out and short-circuited machines. But this discoloration becomes more potent in its suggestiveness as we consider what takes place to produce such a radical, physical change—a change visible to the naked eye, a change positive and far-reaching enough to send the green coloring matter through mica 1-16-inch thick, and to impregnate thick wrapping paper and fibre stock. In the study of this action we need accept nothing but the facts and authority which are beyond dispute by being common knowledge. When we see a piece of mica that was once a beautiful amber color turned green, when we find that it would stand a puncture strain of 10,000 volts while amber color and can be punctured with 1,000 volts since its color has been altered, and we find that it has actually failed to prevent the passage of a current of not over 10 volts, we have a right to conclude that there is a relation between such green discoloration and coincident drop in insulation resistance, and we have a right to carry that conclusion a step further and decide that the short circuit was caused by the chemical transformation of which the color change is evidence.

At least we are justified in a further exploration and examination in the light of the simplest variety of information on a simple chemical action. By so doing we find that it is easy for a varnish to have a chemical effect upon copper. Such action is the rule, rather than the exception, and now by reference to well-known authority we find that this green action is the characteristic one of acids upon copper. The presence of acids near copper is always evidenced by green discoloration. Vegetable acids substitute atoms of copper for atoms of hydrogen in common with other acids. We are justified in concluding that such substitution of copper for hydrogen takes place in a gaseous or semi-gaseous state. We shall now be able to apply the knowledge that vaporized copper has a high conductivity, and we shall then come to an unassailable conclusion that during the time when that mica was being impregnated with that vapor or varnish-copper the insulation of the mica was so reduced that an easy passage was afforded to the 8 or 10 volt current which effected the short circuit.

When we find that the green discoloration may take place in an idle machine and not short circuit it and that short circuits always appear when the green discoloration takes place in a machine which has been constantly in operation, we obtain further proof of a positive nature that acids should not be permitted to enter into coil construction under any circumstances. Not even when they are loaded with black coloring matter to cover up their corrosive action.

In this connection we exploded one of the "Mother Goose" melodies or superstitions of the electrical fraternity, the foolish notion that lubricating oil caused short circuits. Lubricating oil never will, never did, it never can cause a short circuit. If we could design a generator which would run in oil, immersed in oil just as transformers are built, we should undoubtedly produce a successful machine. Why, then, should lubricating oil cause a short circuit? The first electrician who had a short-circuited machine was naturally disappointed and wanted an excuse, and when he found that lubricating oil had penetrated into the coils he accused it of causing the trouble. What actually occurred was this. The lubricating oil came in and stirred up the dormant or satisfied acids of the varnish which he had used. Varnish makers who have essayed to manufacture insulating compounds have on several occasions claimed that their varnishes were oil-proof. This was nothing but a joke, however. Varnish salesmen sometimes attempt to prove that an insulating varnish is oil-proof because they can coat a newspaper with it and the newspaper will hold oil in the open air and away from the heat of operating apparatus. As a matter of fact varnish which is so proved to be oil-proof will unite readily with lubricating oil under a temperature of 150°F. The trouble is that it will not unite homogeneously. The oil unites with one part of the varnish and separates that part from the balance of the varnish so that there are two or three separate and distinct bodies where there was originally but one. In one or both of these the acids are now unsatisfied and they immediately attack the copper, and as before described cause the short circuits which were attributed to lubricating oil.

The oil was absolutely innocent. It is absolutely indispensable and the acids of acid insulations are not indispensable.

Inasmuch as it is feasible, by working in the paraffin series, to make non-acid insulating compounds which have complete chemical affinity for lubricating oil it is perfectly easy to obtain insulation for a machine which will be friends with and welcome all the good insulation which may soak into it from its bearings in the form of oil.

AMERICAN ELECTROCHEMICAL SOCIETY.—At the meeting of the Board of Directors, held in Philadelphia on March 5th, the following-named gentlemen were elected members: A. S. Garfield, Paris, France; Louis S. Cates, Parral, Chir, Mexico; Lee Shepherd, Midland, Mich.; John L. Clawson, Philadelphia, Pa.; F. J. Davis, Lockport, N. Y.; John J. Riker, New York; W. R. Mott, Madison, Wis.; C. F. Carrier, Jr., Bethlehem, Pa.; H. M. Backus, Bayonne, N. J.; J. M. Aylsworth, East Orange, N. J.; E. N. Dickerson, Stovall, N. C.; William Battle Phillips, Austin, Texas; C. R. Walker, Cambridge, Mass.; Walter G. Graves, Cleveland, Ohio; Albert Finck, Cleveland, Ohio; D. R. Warmington, Cleveland, Ohio; C. F. Mabery, Cleveland, Ohio. The following gentlemen were elected at the meeting of the Board of Directors, held in Philadelphia on April 4th: J. T. Morehead, New York; Thomas A. Edison, Orange, N. J.; H. A. Skelton, Foyers, Lockness, N. B., England; Geo. F. Seward, New York; William B. Rankine, Niagara Falls, N. Y.; Van Rensselaer Lansingh, Chicago, Ill.; Augustus E. Knorr, Baltimore, Md.; Richard Threlfull, Birmingham, England; Ottis E. Acker, Niagara Falls, N. Y.; Samuel Newton Smith, Minneapolis, Minn.; B. H. Hite, Morgantown, W. Va.; Edward F. Kern, Lansingburgh, N. Y.; Charles H. Moritz, Niagara Falls, N. Y.; Walter A. Wood, New York; George H. Benjamin, New York; Charles Baskerville, Chapel Hill, N. C.

SYNOPSIS OF ARTICLES IN OTHER JOURNALS.

A Summary of Articles on Electrochemistry and Allied Subjects Appearing in American and Foreign Periodicals.

By Carl Hering.

INDUSTRIAL ELECTROCHEMISTRY.

Electrolytic Refining of Copper.—A very good summary of the progress made during the year 1902, especially in the United States, is given in the *Eng. and Min. Jour.*, March 14th, in an article by Ulke. The great lead of this country is shown by the fact that of the world's average daily production of electrolytic copper which is about 883 short tons, 764 tons or 86.5 per cent. are supplied by the United States; of the balance of 13.5 per cent., Great Britain furnished a little over 8.8 per cent., Germany about 2.75 per cent. and France a little over 1.6 per cent. The United States now produces electrolytic copper annually at the enormous rate of 278,860 tons, which at $260 per ton, is valued at $72,503,600. The copper exports of the United States consist chiefly of electrolytic copper, and for 1902 alone represented a value of $45,485,598, as compared with $33,534,899 in 1901. The value of the exports of copper was exceeded only by the value of the exports of manufactured iron, steel and mineral oils. There are now in active operation, or ready to be placed in commission, 33 electrolytic copper refineries in the world, not including the plant of the Osaka Electrolytic Refining Co., now being constructed at Osaka, Japan. During the past year there has been a notable increase in the quantity of concentrates from the Michigan or Lake Copper Mines, cast into anodes and treated electrolytically. As all Lake copper carries silver to a very noticeable extent, the author thinks it is only a question of time, when all the fine copper produced in the United States will be made electrolytically. It is possible that an electrolytic refinery for treating the converted copper produced on the Pacific Coast, will be built in Puget Sound, where water power is available in large units. The author says that the numerical coefficients in Philip's formulas for area, output, power, cost, current density of copper refineries (see Synopsis, September) are not valid for the conditions in the United States, and should be largely increased, being in most cases made fully twice as large. European refineries seldom use current densities exceeding 10 ampères per square foot of cathode surface; the average density employed in the 23 European refineries is less than 6 ampères per square foot. On the other hand, more American refineries use very high current densities. At Great Falls, Mont., with anodes comparatively low in silver, arsenic and antimony, and with cheap electric power generated from water, current densities up to 45 ampères seem to yield good copper at a profit. Under otherwise favorable conditions, therefore, the profitable use of high current densities, in order to enable the refiner to turn out copper at a very rapid rate, is seemingly limited solely by the excessive losses of current through heating, or boiling of the electrolyte, which occur with current densities above 45 or 50 ampères. Several custom refiners are now casting the anodes very thick and heavy, about 400 pounds in weight, as compared with 180 or 200 pounds, as in former years, partly because the percentage of scrap copper produced with the heavy anodes is only about one-half that with light anodes, say 7 per cent., as compared with about 15 per cent., the weight of the scrap filling being approximately the same in both cases. The American Smelting and Refining Co. are introducing in their Perth Amboy plant the essential features of the Ottokar Hofmann method for the purification of foul electrolytic solution. This process requires the electrolyte to be first neutralized, which is done by adding to it cupric axide (roasted copper matte), the bulk of the solution obtained being increased. This increase may be worked off in two ways, either by treating the surplus solution in a separate system of tanks in which lead anodes and cathodes are used, copper being recovered, while sulphuric acid is set free and used to acidify that part of the electrolyte which is returned to the refinery; or by making blue vitriol, in which case, of course, sulphuric acid must be bought for addition to the refined neutral electrolyte. The author gives a statistical table of the copper refineries of the world.

Artificial Graphite.—The manufacture of graphite electrodes does not seem to have been so large in 1902 as in the previous year, due to the fact that there were fewer new works equipped with such graphite; but the total number of works in which the artificial graphite electrode is used, seems to have increased, as certain valuable properties have been recognized which were not fully appreciated before, such as the resistance of graphite electrodes to oxidation when heated in the air, its high electrical conductivity, and the ease with which it can be machined. In a summary of the artificial graphite industry in 1902, by Fitzgerald, published in the *Eng. and Min. Jour.*, March 28th, he discusses this subject and gives other matters of interest in connection with this industry. A new method for graphitizing electrodes has been patented; the electrodes are placed in piles in an electric furnace, the piles being separated from one another by spaces filled with a "material having a lower co-efficient of electrical conductivity" than the electrodes; the current is then passed through the mass with the result that most of the heat is developed in the material which is in the spaces between the electrodes; the advantage of this method is that large furnaces can be used and yet the resistance can be kept sufficiently high to avoid the use of currents of very high ampèrage. A new process of making graphite in other forms has been patented which is based on metallic vapors acting upon amorphous carbon at the high temperature of the electric furnace. The amorphous carbon, such as the substance obtained from the distillation of petroleum oil, known as "petroleum coke," is placed in a furnace and mixed with a metallic compound, such as ferric oxide; extending from one end of the furnace to the other is a core composed of carbon rods or plates which act as a conductor for the current; on passing a current through the furnace, the petroleum coke is heated to a high temperature, the oxide of iron is reduced and the vapor of metallic iron acts upon the amorphous carbon converting it into graphite. The manufacture of paint from artificial graphite has increased considerably, for it is now recognized that a greater purity and uniformity can be obtained than is possible with a natural plant. The most marked increase has been found in the use of graphite for dry batteries. While artificial graphite has been used for some time as a lubricant, it is only within the last year that the problem of producing a lubricant of artificial graphite for high-grade work has been successfully solved. Experiments have also been made with artificial graphite for coating the grains of high explosives; the spontaneous ignition of high explosives is supposed sometimes to be caused by a static charge of electricity on the grains, this causing a spark which detonates the powder; by coating the grains with graphite the formation of the static charge is prevented.

Calcium Carbide.—According to a report issued by the German Consul in Havre, and discussed in the London *Elec. Rev.*, February 27th, the calcium carbide industry in France has undergone a considerable change in character since the

Bullier patents were finally proclaimed good in the Paris Court of Appeal. The master patent controlling the manufacture of carbide is the property of the Société des Carbures Métalliques, a Parsian company founded by Bullier, which has a capital of 3,200,000 francs. This concern is practically the owner of 17 carbide factories scattered throughout the Alpine districts, and retails its product through the agency of 50 dealers in different parts of the country, who are compelled to sell at the uniform price of 363 francs per metric ton—an arrangement which has been made in order to encourage the use of the material in districts farthest away from the factories, where it would otherwise be more expensive. The annual production is estimated at 18,000 tons. Forty villages are provided with central acetylene installations. In Havre carbide is retailed at 48 to 51 francs ($9.60 to $10.20) per 100 kilos, in lots from 50 to 500 kilos; and at 45.50 to 48.50 in lots from 500 to 2,000 kilos. The existence of the Bullier patent has prevented the importation of any carbide, but the export trade is growing. Since calcium carbide is not itemized in the official export returns, it is not possible to give the exact figures; but it is probably more than 1,000 metric tons per annum at the present time. The material goes chiefly to Brazil, Argentina, Madagascar, the West Coast of Africa, and to China and Japan. Most of the large steamship companies still dislike taking carbide on board, and leave the carrying trade to the "tramps." Some carbide is sent abroad by sailing vessels. One firm in Havre, however, has made a special point of carbide exportation, sending away 300 tons in 1901, as against 100 in 1900. The price of carbide on board ship at Havre is on the average 350 francs per metric ton, a figure which includes 50 francs per ton, the cost of sending it from the works. The expense of shipping carbide to Brazil is 143 francs per metric ton; so that, including everything, French carbide costs about 550 francs per 1,000 kilos in Brazil, unless very large orders are being taken.

In quite a long article in the *Zeit. f. Calciumcarb. Fab.*, March 20th, CARO discusses critically the process patented by Diester.

Use of Carbide of Silicon.—An article on the use of carbide of silicon as a substitute for ferro-silicon, in the manufacture of steel. Manufacturers of steel castings were the first to appreciate the value of carbide of silicon, especially in basic open-hearth work. Much of such work, to insure solid castings, calls for a higher silicon content than can be secured from pig iron that comes within basic requirements. If the addition of ferro-silicon is made to the ladle cold, too great chilling results, and it has been customary to melt it first in a separate cupola; while in certain cases it has been the practice to add it directly to the furnace, but this is accompanied by excessive loss of silicon by reason of its rapid action on the basic slag. In an article in the Cleveland *Iron Trade Rev.*, abstracted in the *Eng. and Min. Jour.*, March 28th, the advantages of carbide of silicon are brought out. It contains 62 per cent. of available silicon, and may be added directly to the ladle during the process of tapping, without previous heating; uniform action is secured and complete solution generally takes place by the time the ladle is full. The carbide has also found extended use in making steel for various purposes for which it is first run into ingots and in which the silicon is very much lower than in steel castings, amounting generally to but a trace. Manufacturers of tool steel have found that the freedom of carbide of silicon from phosphorus and sulphur offers great advantages, and it is therefore used in considerable quantities in the open-hearth practice of such manufacturers and to some extent in crucibles. Operators of the acid open-hearth process have used carbide of silicon in cleaning dirty furnace bottoms; when the hearth becomes crusted over, a small quantity of carbide of silicon is sprinkled over it, and on being heated sets up such a scouring action as to reduce the residue to fluid slag which is readily removed from the hearth.

Electric Steel Furnace.—An illustrated description of the Kjellin electric furnace for making steel, in use in a Swedish plant, is given by BECKER in the *L'Ind. Electrochimique*, March.

Aluminium.—J. B. C. KERSHAW has another statistical article on the present state of the aluminium industry in the London *Elec. Rev.*, March 20th. The number of works producing aluminium either by the Hall or the Héroult process, is now nine, situated as follows: America, 3; France, 2; Germany, Great Britain, Switzerland and Austria, each 1. The power available for the production of aluminium in these nine works is between 36,000 and 40,000 horse-power, all derived from water. The output of aluminium of all nine works is estimated as 7,340 tons in 1901, and 8,000 tons in 1902. Some information is given on the financial conditions of the various companies and the dividends paid by them.

Antimony.—A description and critical discussion of the Izart and Thomas process for the production of antimony from its ores is given in *L'Ind. Electrochimique*, March.

Electrometallurgy.—BEADLE concludes his serial on electrometallurgical problems in the London *Elec. Rev.*, February 27th, giving brief notes on iron, tin, tungsten, nickel, cobalt, mercury and antimony.

THEORETICAL AND EXPERIMENTAL.

Electrolysis of Alkaline Chloride Solutions.—Messrs. FOERSTER and MUELLER made some very extended experimental researches. The theoretical results concerning the process at the anode are summed up as follows: In the electrolysis of aqueous solutions containing chlorine ions at the anode, two negative chlorine ions discharge to form a chlorine molecule. Besides this, there are formed at the anode hypochlorous acid and hypochlorite, either primarily by a negative Cl ion and a negative OH ion reacting and forming HOCl, while at the same time a negative Cl ion and two negative OH ions react and form a negative ClO ion and a molecule of water, or by a reaction of the primarily formed chlorine gas with negative OH ions at the anode. With an increasing ratio of the concentrations of the OH ions to the Cl ions (*i. e.*, for a more alkaline or for a more dilute chloride solution) the development of negative ClO ions, *i. e.*, the formation of hypochlorites, increases. Besides this electrochemical anodic process, there is also a formation of hypochlorite in the electrolyte by a reaction of the alkalies present there with the chlorine gas formed at the anode. As ClO ions are comparatively more easily discharged than Cl ions, and as the former are destroyed when discharged, it is improbable that the hypochlorite formed at the anode remains to a large degree in the electrolyte; the greater the distance from the anode where it is formed, the greater is the chance that it remains in the electrolyte; yet there are always limitations to the possibility of hypochlorite existing in chloride solutions through which a current flows. Chlorate is formed from ClO ions, which have themselves been previously formed either by an electrochemical anodic process or by a chemical process in the electrolyte; in the former, six negative ClO ions react with three water molecules and form two negative ClO_3 ions, plus four negative Cl ions, plus six positive H ions, plus three atoms of O; in the latter process one negative ClO ion, plus two HClO molecules react and give one negative ClO_3 ion, plus two positive H ions, plus two negative Cl ions. The anodic electrochemical formation of chlorate is always accompanied by the development of oxygen gas. The anodic electrolytic generation of chlorate requires the presence of hypochlorite which may either have been formed directly by electrochemical action at the anode, or may have been formed chemically in the inside of the electrolyte; in the latter case it takes some time before the hypochlorite reaches the anode and before the formation of chlorate is started. In strong alkaline or neutral, or in very dilute acid chloride solutions, anodic development of oxygen

may be due not only to the discharge of negative ClO ions, but also to the discharge of negative OH ions. The secondary chemical development of chlorate in the interior of the electrolyte takes place without the development of oxygen; this formation of chlorate occurs to a considerable degree when free hypochlorous acid can exist together with hypochlorite in a large part of the electrolyte; that is, when the chloride solution is slightly acid. The account is published in the *Zeit. f. Elektrochemie*, February 26th and March 5th.

Chlorine and Carbon.—In a previous paper Bolton referred to the direct combination of chlorine with carbon. In the *Zeit. f. Elektrochemie*, March 5th, he now supplements this by showing that if the carbon arc is formed in a chlorine atmosphere in a large space, C_2Cl_6 is formed, but if the reaction goes on in a small confined space, C_6Cl_6 is formed.

Aluminium Valves.—Nodon has continued his experiments with these "valves," as they have been appropriately called, and in the *Comptes Rendus*, February 16th, gives an account of some researches on their internal resistance and their effect upon alternating discharges and telephone currents. He uses an aluminium anode in a concentrated solution of neutral ammonium phosphates, and finds that the capacity of the value may attain as much as 1 farad per square centimeter of aluminium. The thickness of the dielectric forming the condenser is of molecular size, assuming that the dielectric constant is of the order of unity. The capacity has the effect of considerably reducing the e m f of the currents rectified. The apparent specific resistance of the liquid of the valves when open is about 20 to 100 ohm centimeters instead of the 6 ohm centimeters, representing the specific resistance of the electrolyte. No oxide can be seen on the aluminium under the microscope during the passage of a current. The aluminium always presents the aspect of a porous metallic sheet. A telephone current can be measured by rectifying it and using a direct-current galvanometer. Phenomena similar to those obtained with a Wehnelt interrupter may be obtained by putting an aluminium valve in circuit with an alternating current and an induction coil provided with a very light trembler, having a period identical with that of the current rectified. An abstract is given in the London *Elec.*, March 6th.

Ionizing Power of Organic Liquids.—Some experiments were recently made by Di Ciommo to study the effect on the resistance of the mixture produced by adding a solid insulator to an insulating liquid. The account is given in the *Phys. Zeit.*, February 15th, and is abstracted briefly in London *Elec.*, March 6th. His mixtures were made by dissolving sulphur in carbon bi-sulphide, or naphthaline in benzol or toluol, and in every case it was found that the addition of the solid non-conductor diminished the resistance of the other. He also found that the diminution increases rapidly at first with the percentage of the solid dissolved, but less rapidly afterwards, giving the appearance that the resistance tends towards an asymptotic limit. Thus, if a quantity of carbon bi-sulphide has a resistance of 17 million megohms, 1.6 per cent. of sulphur dissolved in it reduces the resistance to 8.5 millions, 3.3 per cent. to 4.6 millions, and 16.5 per cent. to 4.1 millions. But the greatest diminution is not such as to affect the order of magnitude of the resistance. The author concludes that no real ionization takes place.

Radioactivity and Gravitation Energy.—In Forch and Kucera's two articles Geigel recently tried to prove experimentally that the only energy given out by radioactive substance is equivalent to a loss of gravitation energy. Kucera shows in the *Phys. Zeit.*, March 1st, that Geigel's mathematical calculation is incorrect, while Forch repeated Geigel's experiments under modified conditions in which, if there is really an absorption of gravitation energy, he ought to have obtained 40 or 50 times the effect obtained by Geigel, but his results were negative. Forch's article is published in the same journal.

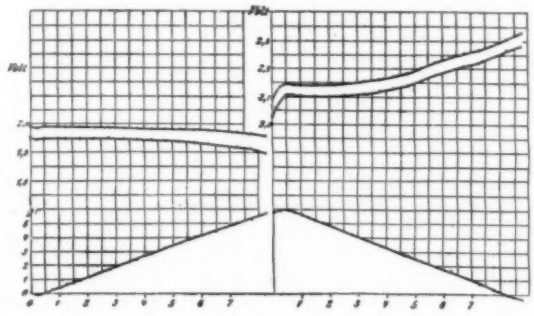
PRIMARY AND STORAGE BATTERIES.

Edison Battery.—Hibbert recently had an opportunity to examine a cell brought to England by H. E. Dick, who is associated with Edison, and gives an account in the London *Elec. Rev.*, March 6th. The cell weighed 18 pounds and had a capacity of 200 watts; it has not yet been in use. Noticeable features are the small distance between the plates, and the compact arrangement in all other respects. In external appearance the containing box, being of nickeled steel, looks much stronger than the wooden or ebonite boxes commonly seen. Some discharge curves are reproduced. The striking feature is the very high percentage of the ampère hour discharge at the higher discharge rates as compared with the normal; the cell is nominally rated at 25 ampères, and then gives about 160 ampère hours at a potential difference of over 1 volt; when the discharge current is raised to eight times this normal value, the ampère hours, with a continuous discharge down to 1 volt, ar practically 125. He thinks that no makes of lead cells would offer a cell giving 75 per cent. of its normal capacity at eight times its normal rate. "During discharge, the density of its liquid is not diminishing, but rather increasing. Hence the ability to call on a greater fraction of the available energy at a higher discharge rate." The manufacturers claim that there is no local action. The ampère hour efficiency, when ten or twelve days intervene between charge and discharge, is only 2 or 3 per cent. less than when the discharges immediately follows the charge. "The general result of an examination of the cell is to remove some antecedent skepticism, and one feels that there is a serious competition to the lead cell not far away. The final decision will appear when the cells are offered to the public and get tried by the infinitely varied rough usage and nescience of the general public. A preliminary to that stage will be reached when an adequate report has been made by outside authority. I understood Mr. Dick to say that this is being arranged for, and till then we must wait with such patience as we can command."

Some abstracts on this battery, taken from American journals, are given by that author in the same journal of February 27th. Editorially that journal in its issue of March 6th says, after examining this cell: "The cell is a model of excellence in mechanical construction; being composed mainly of steel, it afforded the designers a rare opportunity of which they have availed themselves to the full. * * * If all the claims advanced for this cell, or even a part of them, are fulfilled, we may look for more important results from its introduction."

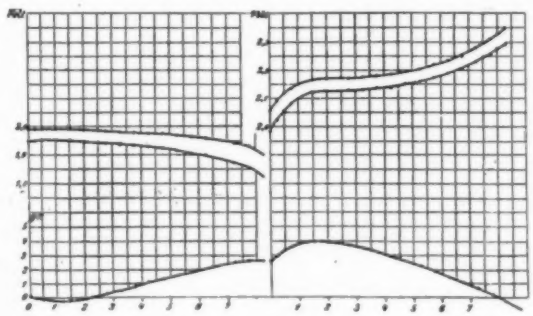
Lead Accumulator.—The question of whether a Planté or a pasted positive plate will withstand the action of repeated partial charges and discharges better, has been the subject of much discussion, and is a matter of some importance in batteries used as "buffers," as, for instance, when they are used as equalizers in railway and lighting plants. While actual tests are the best way to settle such a question, yet even in such a test the results could apply only to the specific plates tested, and hardly to types of plates. M. U. Schoop has made some tests which he described in the *Elek. Zeit.*, March 19th, and while they are of interest it hardly follows that the conclusions can be applied to the two types, but only to the specific plates used by him. The gradation from a Planté plate to a Faure plate, may be a very gradual one, after they are well formed, and their difference can hardly be expected to be typical; it is in their process of manufacture that they are typically different. In the tests of Schoop, two accumulators, each having one positive and two negative plates, were compared, which for a one-hour discharge down to the same voltage, had equal capacity and differed only in so far as the single central positive plate in the one cell was a pasted grid plate and in the other a Planté plate, the two negative plates being exactly the same in both cells. The purpose was to study the behavior of pasted and of Planté positive plates in buffer service. The main results are as follows: The determi-

nation of the "true" total surface of a positive or negative accumulator electrode is so very difficult that it may be questioned whether it will ever be possible to determine numerically the true surface which takes part in the electrochemical reaction, its geometrical form being very complicated and changing from moment to moment. The apparent surface of a pasted plate or of a Planté plate, as found from length and breadth, is extremly small as compared with the true surface. It is not quite correct, therefore, to speak of a true current density, and the quotient of the apparent surface to the current is without value for the knowledge of the true current density, as the lines of current are nearer together at prominent points than at points deeper in the plates, and as these lines of current



PLANTÉ PEROXIDE PLATE.

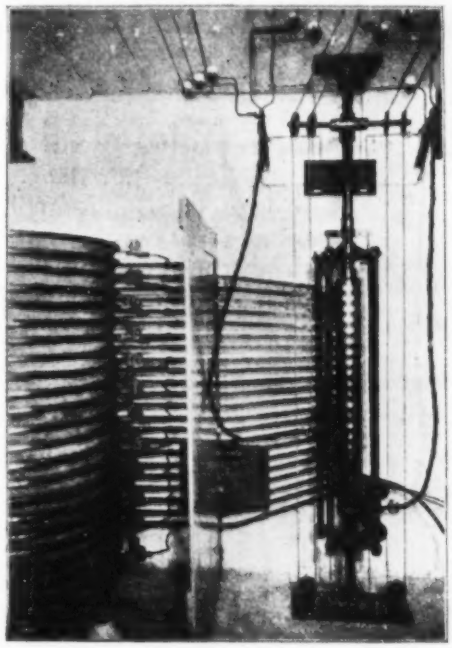
are continually changing their path. The true surface of a so-called "sulphated" positive plate is so small that in a charge with the usual current, such a high density exists that great quantities of ozone are formed. With positive Planté plates the acid diffusion is better than in pasted plates, so that in very quick charges and discharges the active mass is utilized to a greater degree in the former than in the latter. But this advantage of the Planté plates is counterbalanced by the fact that the internal resistance of a Faure accumulator having the same capacity, acid density and density between the plates, is smaller than that of a Planté accumulator; in respect to buffer service the Faure accumulator is therefore thought to be superior to the Planté accumulator. He studied the charge



PASTED PEROXIDE PLATE.

of weight of positive plates during charge and discharge in the following way. Between two negative plates a positive plate was placed, and the latter was suspended on one arm of a balance, so that the change of weight could be studied during the whole time of the tests. He again compared a pasted positive plate in one case with a Planté positive plate in the other case. As the chemical reactions are the same in both cases, the differences in the behavior of both types of plates represents the different conditions of acid diffusion in the plates. One of the adjoining diagrams refers to a pasted peroxide plate, the other to a Planté peroxide plate. The upper curves in both diagrams are the ordinary discharge and charge curves of e m f, while the lower curves give the change of weight in grams. The ordinates represent ampère hours. The acid density was in both cases 1.167 at 19° C., and the current 3 ampères. The two diagrams show very clearly the difference in the conditions of diffusion in both types of plates; the diffusion is much better in the Planté plate than in the pasted plate.

Preparation of the Active Mass for Lead Storage Batteries.—LEIMER begins an article in the *Centralblatt f. Accum.*, March 1st, in which he gives an account of an experimental investigation of the value of various substances which were added to a mixture of water and lead oxides, in order to make the active mass more adherent and durable. Although the water has some hardening effect it is entirely insufficient; and while the sulphuric acid when it afterwards comes into contact with the mass, increases the hardness, there is also the danger of a strong development of gases which may destroy the structure of the active mass. He made experiments with nine different substances: sulphuric acid sp. gr. 1.17 sulphuric acid sp. gr. 1.20, mixed with pure English glycerine, aqueous solutions of phenole, salicylic acid, acetic acid, pyridine, an



SWITCH FOR TRIBELHORN ACCUMULATOR.

alcholic extract of cobbler's wax, amber dissolved in a mixture of turpentine and carbon bisulphide and finally gelatinous chromium hydrate. The exact composition of these solutions is not given, but it is stated that 10 grams of each of these solutions was mixed with 300 grams of minium. The further preparation of the plates is described. The article is to be concluded and the results will then be published.

Tribelhorn Storage Battery.—An illustrated description is given in the *Centralblatt f. Accum.*, February 1st, of this accumulator, the characteristic feature of which is that the cone-shaped leaden cells are placed one above the other, like in the old Voltaic pile, or in Salom's lead-reduction apparatus, the cells themselves forming the plates. The main advantage is the great saving of space which is claimed to amount to 50 to 75 per cent. The installation of such a battery in a lighting plant is described; it gives 840 or 1,200 ampère hours if discharged in three or ten hours, respectively. It takes about two hours to build up a column. The adjoining diagram shows an end-cell switch of very simple construction, connected to such a column. The contact rings, which are insulated from each

other, are mounted on a cylinder, the contact springs being moved on the cylinder parallel to its axis and being also adjustable in the direction of the periphery. This switch may be placed at any distance from the battery and is moved from a distant point by a mechanical transmission device; for instance, by a rope acting on the sliding contacts. In order to enable one to place the switch in the immediate neighborhood of the battery, it is made of acid-proof material.

Sal-Ammoniac.—Rosset in the *Centralblatt f. Accum.*, February 1st, gives a description of simple practical methods for rapid determinations of the purity of commercial sal-ammoniac which is to be used for galvanic cells. For this purpose it should be quite pure and should not contain too large quantities of sodium chloride or ammonium sulphate. The two methods which he found most practical are to determine the specific gravity of the solution at a given concentration and the temperature decrease due to the solution in water. The specific gravity method is most sensitive for strong solutions, and the temperature-decrease method for dilute solutions. He prepares a saturated solution with a large excess of the salt and determines the specific gravity at 15° C. If it is greater than 1.0766 (10.25° B.), the sal-ammoniac is not pure. The absence of sulphates, and especially of ammonium sulphate, is shown when barium chloride or acetate does not give a precipitate. He then makes a solution of the concentration used, and determines the temperature decrease; as this takes place after thirty or forty-five seconds, it is necessary to work quickly; the water and the salt must of course have the same temperatures at the start. If 25, 50, or 75 grains of sal-ammoniac are dissolved in 250 cc water, pure sal-ammoniac gives a temperature decrease of 6, 11.5 and 15° C., respectively; if the sal-ammoniac contains 10 per cent. sodium chloride, the temperature decrease is 5.5, 10.75, and 14.25° respectively.

Galvanic Cells.—An article by Mugdan is begun in the *Chem. Zeit.*, March 15th, in which he intends to discuss the possibility of commercial carbon cells. In the present installment he deals with the principles of the galvanic cells in general; this is first briefly discussed from the point of view of the electrolytic dissociation theory and afterwards from the basis of the principles of thermodynamics. In the light of the second law of thermodynamics he considers the galvanic cell to be the most simple ideal machine for obtaining the maximum possible mechanical work from a given process.

Standard Cells.—Jaeger contributes another article on some recent researches, especially in connection with the Weston cadmium standard cell. It had been found that some cadmium cells showed irregularities when used near 0° C., but this was found to be due to the use of too strong an amalgam, containing 14.3 parts (by weight) of cadmium per 100 parts of amalgam (*i. e.*, 1 cadmium per 6 mercury); such an amalgam undergoes a change at 0°. If a slightly more dilute amalgam is used, there are no irregularities whatever. In the Reichsanstalt, about 80 cadmium cells, partly with 12 per cent. and partly with 13 per cent. cadmium amalgam were tested, and although they were kept for a week at zero temperature, no irregularities were found. The supposition that the irregularity found in the cells with the 14.3 per cent. amalgam were due to a change of the electrolyte cadmium sulphate, has been proved to be wrong. There is no change whatever in the cadmium sulphate, and if a 12 to 13 per cent. amalgam is used, the cadmium cell is absolutely reliable and very convenient on account of its small temperature coefficient. The article is published in the *Centralblatt f. Accum.*, March 1st.

Lighting of Railway Cars.—Goetze begins an article in the *Centralblatt f. Accum.*, March 15th, in which he discusses the various systems of electric lighting of railway cars.

MISCELLANEOUS.

Steam Power versus Hydraulic Power. In the *Elek. Zeit.*, February 19th, Hecker discusses the prospects of a proposition made in a special case in practice, to erect a hydraulic installation, which if all the available water is utilized, would give a power of 600 horse-power. The cost of the hydraulic plant alone, without the electric plant, is estimated at about $375,000, while that of a steam plant of the same capacity is estimated at $100,000. But as the cost of operation is higher for the steam plant than for the hydraulic one, the question arises under which condition one of them is financially more economical than the other. This is the question which the author discusses under certain suppositions concerning interest, etc., and reaches the conclusion that the hydraulic plant is more economical than the steam plant only when the load factor is more than 60 per cent. during the total time.

Mineral Spring Waters and Physical Chemistry.—Referring to some recent critical papers, Juettner discusses the abuse of the electrolytic dissociation theory and of the teachings of physical chemistry, by physicians in charge of mineral springs. For instance, one physician claims that it is only in natural mineral waters that the salts are dissociated into ions and that they are therefore healthful, while in artificial salt solutions he claims that the ions are not ionized; such absurd claims are then reprinted in many prospectuses. A claim made by another physician is that the water from a certain mineral spring is very healthful because its electrical conductivity is 6.1 times that of pure distilled water; but he does not say that ordinary water has a still better conductivity. The electric charges of the ions are said to be the property which makes them healthful. The author analyses critically several tests of mineral waters made by methods used in physical chemistry. The ordinary chemical analysis is quite sufficient and the application of the teachings of physical chemistry is a "luxury." There is great danger that these physicians' abuse of the teachings of physical chemistry will bring it into disrepute. The article is contained in the *Zeit. f. Elektrochemie*, February 26th.

Copper Cadmium Alloys.—Denso tried to determine which compound is crystallized out from molten copper cadmium alloys having an excess of cadmium. Alloys of various compositions were tested, and from all of them the same compound $CuCd_3$ was obtained. For further details see *Zeit. f. Elektrochemie*, February 12th.

The Electric Club, Pittsburg, Pa.—The first annual report of the Electric Club, Pittsburg, Pa., is issued in the form of a very neat illustrated booklet under date of March 19, 1903, the anniversary of the Club's organization. This pamphlet, of artistic design, gives the constitution and membership of the Club, the scope, plans and personnel of the various committees, and an outline of the work accomplished and proposed. A feature of this work which has proven very valuable is the formation of classes for the study of technical subjects under the instruction of various engineers of the Westinghouse Electric and Mfg. Co. These classes, or "sections," constitute "self-exciting" engineering societies within the parent body, each section pursuing a separate and definite line of study. As a further aid, there is a well-equipped technical library, including the various electrical and mechanical magazines. The social side of life is directed by the committee in charge, of which not the least is that known as the Ladies' Committee, an ever-to-be-desired element in any club. The Club has proved to be a decided success.

Geological Course.—Harvard University offers a summer course of five weeks in geological field work in the Rocky Mountains, beginning about July 1st. Prof. Charles H. White, of Harvard University, will have charge of the course. The field selected includes the higher groups of mountains in Southwestern Colorado.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

BY GEORGE P. SCHOLL.

ELECTRIC FURNACES AND FURNACE PRODUCTS.

Electric Furnace. P. L. T. Héroult, La Praz, France, Assignor to Société Electro-Metallurgical Française, Froges, Isère, France. Patent 721,703, March 3, 1903. Application filed October 11, 1900.

This furnace was designed by Héroult for the purpose of obtaining metals such as chromium, manganese and iron, and generally substances which tend to combine with carbon. In order to avoid as much as possible the introduction of carbon from the electrodes into the product, two separate arcs in series are employed, which play through an insulating layer of slag between the fused conducting material on the one hand and the two electrodes on the other hand. Fig. 1 shows the furnace in cross section. It consists of a crucible *a* of a suitable

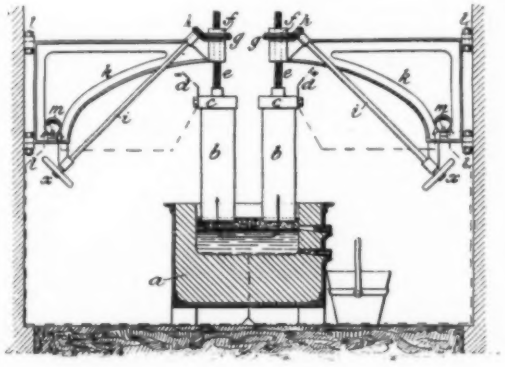


FIG. 1.—HEROULT'S ELECTRIC FURNACE.

refractory material, inclosed in an iron casing and provided with two tap holes, the lower one for the metal, and the upper one for the slag. The two electrodes are supported by cantilever frames *k*, *k*, and can be raised or lowered by hand wheels *x*, *x*, and suitable gearing. In order to insure the distinct formation of the two arcs, a shunt circuit is arranged between each electrode and the fused material, with voltmeters *m*, *m*, the indications of which serve to constantly verify and regulate the position of the electrodes and to indicate, whether the furnace is working properly or not. Either continuous or alternating currents can be used, and polyphase currents could be employed by providing more than two electrodes with the means described of regulating their positions. It is stated that the arrangement is applicable not only to the reduction of ores, but also to the decarbonization of substances treated with oxidizing slags or with an air blast, such as steel or iron. The slag in this apparatus forms the resisting medium, in which the heat is produced. The furnace is evidently an improvement on the one described in ELECTROCHEMICAL INDUSTRY, Vol. I, page 63.

Electric Furnace. Albert A. Shadé, Chicago, Ill. Patent 722,411, March 10, 1903. Application filed May 15, 1902.

This furnace shows a more simplified construction than the one described by the same inventor in patent No. 713,923, of November 18, 1902 (ELECTROCHEMICAL INDUSTRY, Vol. I, page 187). The zigzag passages of the latter have given place to a single inclined passage in this one, with a refractory wall of fire-brick or like material and a transversely curved bottom. Three pairs of carbon electrodes extend into the lower end of this passage. Magnets are provided again as in the former patent, and arranged below the arcs in such a manner, as to deflect them onto the material to be treated. Metallic shield plates are employed in order to prevent the lines of force of adjacent magnets to interfere with each other. Peep holes are arranged opposite to the arcs. In order to feed the electrodes into the furnace, as they are consumed, they are provided on one side with spirally-arranged grooves, forming partial screw threads, which are engaged by a threaded rotating shaft, which is actuated by a hand wheel. The masonry construction of the furnace is inclosed with metallic plates, and space is left between the masonry and the plates, to be filled with asbestos or other insulating material. The material to be treated is fed into a hopper and passes into a chamber, where provision is made to heat it by the waste gases from the furnace. It then falls on the inclined passage, where provision is made for still further heating it before it comes under the influence of the arcs. For this purpose three pairs of gas burners are arranged between the charging end of the furnace and the first pair of electrodes, directed downwards in order to play on the bottom of the inclined passage. The material is in this manner thoroughly dried and considerably raised in temperature, and the action of the arcs is facilitated. It then passes successively through the three arcs and is gradually fused, and the number of the arcs and the length of the inclined passage are so arranged, that the material, when it reaches the discharge spout, is entirely fused. It is drawn into a suitable receptacle and subjected to further treatment. It is stated that the furnace may be used for smelting or fusing all kinds of material requiring an intense heat for reduction, and is especially adaptable for reducing silica or silica compounds in the process of making glass or like vitreous materials. When the furnace is used for glass making, it is evidently intended to have the liquation of the glass take place in another furnace. A contamination of the melt by carbon particles falling from the electrodes would probably also be likely to take place.

Method of Producing Compounds Containing Silicon, Oxygen and Carbon. E. G. Acheson, Niagara Falls. Patent 722,792, March 17, 1903. Application filed November 20, 1902.

Refractory Material. E. G. Acheson, Niagara Falls. Patent 722,793, March 17, 1903. Application filed November 20, 1902.

These two specifications protect, respectively, a method of producing compounds containing silicon, oxygen and carbon, and the resulting products. Mr. Acheson discloses methods of treating carbonaceous and siliceous material, whereby silicon-oxygen-carbon compounds are produced, which he designates by the general term "siloxicon." These compounds are said to be very refractory under high temperatures, insoluble in iron, inert towards acid or basic slags, and readily shaped into any desired form. Instead of mixing silica with a small excess of carbon, over that required to reduce it, and to form carborundum, the amount of carbon in the mixture for the production of the compounds under consideration is insufficient for the reduction of all of the silica. The reduction is, therefore, incomplete, and a certain amount of oxygen is retained in chemical combination with the silicon, and compounds containing silicon, oxygen and carbon are formed. Thus a compound corresponding approximately to the compounds Si_2C_2O and Si_7C_7O, and analogous compounds have been produced. In order to manufacture these compounds satisfactorily, it is necessary to keep the temperature of the electric furnace below that required for the formation of carborundum, as decomposition takes place at or about that temperature, possibly in accordance with the equation $Si_7C_7O = 6\ SiC + Si + CO$. The silicon and carbon monoxide escape

from the furnace as vapor and gas, while the carbide of silicon remains behind as crystals of carborundum. In order to carry out the method, 33⅓ per cent. of powdered carbon, and 66⅔ per cent. of powdered silica are mixed thoroughly together. When the mixed materials are fine-grained, a little saw-dust is added to increase the porosity, and the proportions of the above mixture are modified in view of the silica and carbon content of the saw-dust. The silica content of the carbon is also considered in the preparation of the charge. The mixture is then charged into the electric furnace and upon subjection for a suitable period to a temperature below that required for the production of carborundum, the product is found to consist of the above-described chemical compound containing silicon, oxygen and carbon. In a concrete case the furnace was 56 inches long, 20 inches wide and 14 inches deep, and contained two cores of graular coke, 3 inches in diameter and 48 inches long. It was filled with the described mixture, and the current was started with 85 volts and 500 ampères. The volts remained practically constant, while the ampères soon increased to 600, after which they remained practically constant to the end of the operation, which lasted nine hours. After cooling and opening the furnace, all of that part of the charge occupying the space between and for a certain distance around the cores was found to be converted into loose graular or pulverulent amorphous material, which was gray-green, when cold, and light-yellow, when heated to 300° F. or over. An analysis of the material gave the following composition by weight: Si = 57.7; Ca = 25.9; Fe = 2.1; Al = 0.4; Ca = trace, Mg = trace, O (by difference) = 13.9.

Crucibles made of "siloxicon" are found to be superior to the crucibles of clay or graphite and clay, as they are not acted upon by molten metal or slag, nor are they worn away laterally by the action of the fuel or furnace gases. It is considered preferable to utilize the self-binding properties of "siloxicon" in its various applications to articles or linings. A suitable binding agent, such as tar, asphaltum, molasses, etc., may, however, be mixed with the material and the resultant mass molded into the desired forms, which may then be burned or may be used without burning. When the "siloxicon" is to be used as a furnace lining, it is sometimes preferable to prepare the mixture and tap or ram it into place, where it later receives its final heating. "Siloxicon," as will be seen from the above description, represents another addition to the list of valuable products, which Mr. Acheson has placed at the disposal of the metallurgist, through his persistent and indefatigable work in extending and perfecting the use of the electric furnace.

Method of Subdividing Blocks or Ingots. Joseph Scales, of Niagara Falls, N. Y., assignor to Union Carbide Co. Patent 722,750, March 17, 1903. Application filed January 13, 1903.

This invention is an amplification of the inventor's former patent for a method of subdividing blocks or ingots of calcium carbide, patent No. 719,882 of February 3, 1903 (Electrochemical Industry, Vol. I, page 251). In that patent a method was described for detaching large pieces of carbide from the ingots produced in calcium carbide furnaces, especially of the Horry type, as used by the Union Carbide Co. at Niagara Falls. The method consisted in drilling one or more holes into the block of calcium carbide, while it is still in a highly-heated state, and at the same time injecting water or steam into the cavity, preferably through the drill, thus effecting a local disintegration of the carbide. Another method consisted in effecting such local disintegration by a jet of steam or water alone, without the use of the drill or any other mechanical appliance. The present specification amplifies the claim, by broadly claiming the use of reagents in general, on any blocks or ingots. The inventor says: "My method may be applied to other materials than calcium carbide, and other reagents than water, air or steam may be employed, the particular reagent being chosen with reference to the character of the material, upon which it is desired to operate. It is essential only that the reagent be capable of acting upon the block or ingot in a heated state, to cause a local solution or disintegration, which will assist its subdivision."

Apparatus and Processes for the Electrolytic Production of Metals and Compounds.

Secondary Electrode for Electrolytic Apparatus. Paul Imhoff, Liverpool, England, assignor to United Alkali Co., of Liverpool. Patent 722,583, March 10, 1903. Application filed December 17, 1902.

The object of this invention is to provide a secondary, or as it is usually called, a bi-polar electrode, for use in the manufacture of chlorates. The inventor wants to do away with the use of the expensive all-platinum electrodes, as used at present, and, therefore, constructs his electrodes out of an anode built up of platinum wire and a cathode of a cheaper conducting material in the form of wires, rods, plates, bars, strips or gauze. Both anode and cathode are built upon opposite sides of a non-conducting supporting plate or body of slate, glass, stone or other suitable material. The necessary connections between the anode and cathode are made by bringing the ends of the platinum wires or strips of the anode around the edges of, or through holes in the supporting plate, and welding wrapping or otherwise fastening them to the cathode material. Fig. 2 represents a cross-section of the construction, showing the anode *a*, consisting of a platinum wire. *c* is the supporting plate of non-conducting material, which separates the anode and cathode material, and *b* is the cathode in the form of a rod. Distance pieces or strips *d*, keep the anode and cathode material from contact with the plate *c*. The platinum wires of the anode are passed through holes in the supporting plate. Very good results are said to be obtained with a cathode of iron or of carbon.

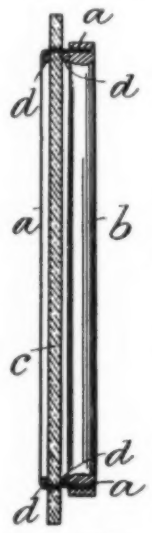


FIG. 2.—BIPOLAR ELECTRODE.

Manufacture of Titanous Chloride. Howard Spence, Manchester, England. Patent 723,217, March 17, 1903. Application filed August 15, 1902.

The inventor claims to have discovered a new crystalline titanium chloride compound, produced by electrolysis, having chemical and physical characteristics different from the compound known up to now and described by Glatzel already in 1832, under the formula $Ti_2Cl_6 + 8\ H_2O$. The new compound is stated to possess important qualities for commercial use as a reducing agent in various manufactures, its reducing power being much greater than that of the existing chemical reducing agents, such as stannous chloride. The method of procedure consists in subjecting a solution of titantic chloride, $TiCl_4$, obtained by dissolving orthotitanic acid in hydrochloric acid, to electrolysis. The solution may suitably contain about 25 per cent. of $TiCl_4$. The cell, in which the electrolysis is carried out, is divided by a porous diaphragm into two compartments, and contains a cathode of lead and an anode of carbon. The solution of titanic chloride is introduced into the cathode compartment, and a dilute acid solution, *f. e.*, dilute hydrochloric acid, is introduced into the anode compartment. Satisfactory results are said to be obtained with a current density of about 200 ampères per square meter, at a tension of from three to four volts. On closing the circuit the $TiCl_4$ solution is readily and rapidly reduced to Ti_2Cl_6, the liquor being kept at the ordinary or at a slightly elevated temperature. More than 90 per cent. of the $TiCl_4$ is stated to be converted into Ti_2Cl_6. The chlorine gas given off at the anode may be utilized as usual. The solution of Ti_2Cl_6 thus produced is then concentrated, by preference at a lower temperature and under

required pressure. Unlike Glatzel's solution, which decomposes during evaporation, this solution is said to remain quite stable, and any slight decomposition, occurring at the commencement of the concentration, is due to the decomposition of some $TiCl_4$, which has escaped reduction during electrolysis. The concentration of the liquor continued until a specific gravity of about 1.5 at 650 to 70° C. is obtained, yields on cooling an abundant crop of crystals of the new compound. This product is of a lilac shade of color, showing more violet when damp, while Glatzel's compound was green. The new compound forms a very stable body, soluble with extreme readiness in water to a clear solution. No analyses are given by the inventor to prove that his compound is really new. Ti_2Cl_6 has been described as a violent compound by O. v. d. Pfordten (Liebig's Annalen, 237, 217), but unlike the compound described above was hygroscopic and dissolved on heating to a violet solution.

Reducing Indigo. R. Mueller and Otto Schwab, Hoechst-on-the-Main, Germany, assignors to Farbwerke, vormals Meister, Lucius & Brüning. Patent 723,007, March 17, 1903. Application filed July 29, 1902.

The inventors have found that the reduction of indigo may be practically carried out by means of the electric current and in presence of warm sulphite solutions. In this process the sulphite or the hydrosulphite resulting therefrom, serves as a carrier of the reducing action of the electric current, that is to say, the electric current does not directly reduce the indigo, but it reduces the sulphite to hydrosulphite and the latter first reduces the indigo. The process may be conducted in such a manner as to directly obtain a solid indigo-white product, pretty stable even when exposed to the air. Care has to be taken that the liquid does not become too alkaline during the electrolysis, otherwise an indigo-white solution will be the result. The best mode of operation is stated to be as follows: 300 grams of indigo paste of 25 per cent., with 415 cubic centimeters of a solution of sodium sulphate of about 30 per cent. strength, 415 cc of a sodium sulphite solution, containing about 10 per cent. of SO_2 and 55 cc of a sodium-bi-sulphite solution, containing about 40 per cent. of $NaHSO_3$. The electrolysis takes place in a vessel without diaphragm, with stirring, at a temperature of about 80° C. The electrodes are of lead and the current density is about 3 to 5 ampères per square decimeter. The density of current and the voltage may vary between wide limits. After about 24 ampère hours the indigo is reduced, and the indigo-white resulting may be filtered and obtained free from the above-mentioned salts by washing it with hot water.

Electroplating Apparatus. Joseph Walters, Sumter, N. C. Patent 721,402, February 24, 1903. Application filed March 22, 1902.

This invention relates to an improvement in electroplating apparatus, and more particularly to means for cleaning and buffing, as well as plating, the object being to construct a simple, portable apparatus, so constructed that it can be used interchangeably for preparing articles to be plated and then for plating them. Fig. 3 shows the construction of the apparatus. A represents a plating tank, filled with an electroplating solution, in which suitable anode plates 1 are suspended and connected to a source of current. A frame 2, resting on the top of the tank, supports two uprights 3, adjustably fastened by screws 4. The lower ends of the uprights are provided with bearings 6a, for supporting a rod or shaft 6 of metal, preferably copper, which serves as the cathode of the apparatus. This shaft is held stationary, by bending it upwards to form an arm 7, fastened to one end of the frame by a fastening device 8. A binding post 9 on this arm is connected with the negative terminal of the source of current. A drum 10, of non-metallic material (preferably wood), is mounted to revolve on shaft 6, and this drum is provided with numerous perforations, in order to permit the entrance of the solution in which it is immersed. The shaft 6 is provided with a series of conducting arms 11 within the drum, which extend to points in proximity to the drum. A shaft 13 is mounted in the uprights, bearing a pulley 14, which by means of a driving belt 15 transmits motion to the drum. The inventor states that by this apparatus the cleaning and preparing of the articles to be plated can be effected without scratching them. The articles can be placed in the perforated drum, the apparatus

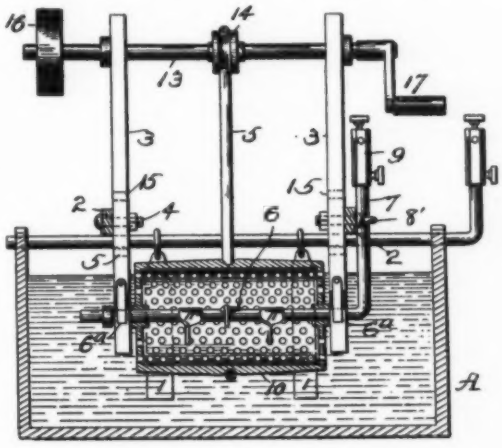


FIG. 3.—ELECTROPLATING APPARATUS.

set over a lye kettle, and then by turning the crank 17, the articles will be made to roll over each other and become perfectly clean. As the rotating of the objects under water or solution prevents them from becoming scratched, the apparatus can then be removed to a washing tank, and the articles can be washed in the same manner. After the articles have been perfectly washed, the apparatus, with the articles still contained in the drum, is placed in position on the plating tank. By applying power to the drum, the articles will then be made to rotate in the plating solution, where they will not only become perfectly plated, but by rubbing against each other will be burnished or polished to such an extent, as to avoid the necessity of much of the subsequent finishing, which has been necessary heretofore.

Silver Plating or Gilding Process. Joseph A. Schiele, Brussels, Belgium. Patent No. 722,148, March 3, 1903. Application filed September 1, 1902.

The invention aims at avoiding the use of copper as a preliminary deposit, preparatory to silver plating or gilding surgical instruments, household utensils, covers, etc., in order to escape the troubles caused by the copper when the plating has worn off in spots. For this reason a preparatory bath is used of a special composition, by which it is claimed that an absolutely adherent and resistent coating can be obtained, which allows silver plating or gilding to be applied in the usual manner. The silver plating is claimed to be more adhesive, more durable and finer than that done in the usual manner. The preparatory bath consists of an ordinary tinning bath with the addition of a solution of salts of aluminium and magnesium. If a bath of 10 liters is required, 500 grams of pyrophosphate of sodium are dissolved in 9 liters of distilled water. Then 100 grams of crystallized protochloride of tin are placed in a cloth or sieve and immersed in the solution until complete solution has taken place. The preparation thus formed constitutes the well-known bath, in which objects of iron, etc., are tinned, but such a coating is said not to be suitable for a silver plating or gilding coating, which would peel off on the least rubbing. Therefore, to this first bath is added a solution of 50 grams of nitrate of aluminium and 50 grams of nitrate of magnesium in 1 liter of distilled water. This mixture constitutes the electrolyte, thin plates of tin and aluminium are

used as the anode, while the cathode is formed by the objects to be plated. The metallic objects, previously well polished and cleaned, are put into the bath and are claimed to become coated with a layer, consisting of an alloy of tin, aluminium and magnesium, after which they are thoroughly rinsed and put into a silver-plating bath. It is claimed that by the addition of the aluminium and magnesium salts the coating of tin acquires durability and adhesive power, especially to iron. Not only iron and steel, but other metals, which up to the present could not be silver plated or gilded, without the use of the copper bath, can be treated in the manner described. It is also stated that as the deposit is whiter than in ordinary silver plating; the troublesome burnishing operation by means of agate or blood-stone can be dispensed with, the finishing being effected with the aid of a polishing cloth and paste or powder.

Storage Batteries.

Reversible Galvanic Battery. Thomas A. Edison, Llewellyn Park, N. J. Patent 721,862, March 3, 1903. Application filed November 28, 1902.

In this specification Mr. Edison describes another modification of his alkaline storage battery, with an electrode composed of oxide of cobalt, preferably mixed with metallic mercury or with metallic mercury and copper or silver, whereby a great proportion of the cobalt oxide is kept in electrical contact with the electrode. The preparation of the electrode he describes as follows: "Dried oxalate of cobalt is first produced in any suitable way and is ignited and kept at a low temperature in the air, until it has been wholly decomposed to form the anhydrous oxide of cobalt. This oxide is then mixed with, preferably, about 15 per cent. of precipitated oxide of mercury, if an electrode is to be obtained, composed of cobalt and mercury, or, if desired, it may be mixed, preferably, with about 25 per cent. of finely-divided metallic copper and 6 per cent. of precipitated oxide of mercury, if the resulting electrode is to be formed of cobalt and a combination of copper and mercury. These proportions may, of course, be varied, but those indicated give good results. I find, in fact, that by increasing the proportion of mercury, or of mercury and copper, a larger proportion of the cobalt is rendered active; but the increase in efficiency is secured at a sacrifice of lightness and economy. Silver may also be employed in place of the copper; but it possesses the objection of being too expensive at the present time for economical use. The mixture of oxide of cobalt and oxide of mercury, or of oxide of cobalt, metallic copper and oxide of mercury is then mixed thoroughly, formed into briquettes and utilized in any desired manner, preferably, by being supported in perforated nickel-plated pockets or receptacles, which in turn are crimped in position within plates or grids. An electrode, containing a mixture of cobalt and mercury, or of cobalt, mercury and copper or silver, is preferably employed in a solution of say, 20 per cent. of potassium hydroxide in water, opposed to a depolarizing element containing nickel hydroxide as the active material, mixed with foliated or flake graphite. When such a combination has been charged and recharged several times, its average voltage is about 1.10 volts. When such a combination is in a fully charged condition, the nickel hydroxide is raised to a very high state of oxidation, and the cobalt is reduced, so far as its active particles are concerned, to the metallic state. On discharging, the nickel hydroxide reverts to a lower condition of oxidation, while the metallic cobalt is oxidized. Owing to the relative ease, as compared to cobalt, with which mercury and copper reduce, the added mercury or copper or silver, if used, will be reduced to the metallic state when the battery is first charged, so as to procure good electrical contact between the active cobalt particles. Since the cobalt on discharge oxidizes much more readily than either mercury, copper or silver, the latter materials remain in metallic form, and their presence serves wholly to assist the electrical conduction between the particles of the active material." Mercury, copper or silver are added by preference to the oxide of cobalt for the purpose of maintaining contact between the active materials, but any insoluble conducting material, preferably in flake form, such as flake graphite, can be used for this purpose.

Electrode for Reversible Galvanic Batteries. Herbert Cottrell, Newark, N. J. Patent 722,947, March 17, 1903. Application filed September 13, 1902.

The invention consists in the construction of the electrode, which is made either wholly or in part of carbonized cellulose, and in which this carbonized material serves both as the absorbent for the materials to be rendered active in the battery and its casing. The plates are preferably formed of carbonized cotton textile fabric, arranged in several layers in conductive contact with each other. They may be made of a comparatively finely-woven cotton fabric and should be carbonized to a soft degree only. They may be permeated with metallic salts in solution, such as lead salts, or they may be coated with a material to be rendered active in the battery, *f i* lead or lead oxide. These plates are then inclosed between exterior plates made preferably of coarser fabric of a more open weave and carbonized to a higher degree, and usually treated with liquid hydrocarbon and again carbonized, to give them greater strength and rigidity. The whole group is then subjected to sufficient pressure to insure uniformity of thickness, and the edges are joined by an electrically conductive cement, so as to form a homogeneous plate. The accompanying Fig. 3, shows the plate, where *a* represent the interior layers of soft fabric, *b* the outer more rigid plates, *c* the metallic frame, and *d* the joining of the edges by a suitable cement. It is claimed that this structure favors the absorption and the evolving of gases, so that a rapid charge may be made without disintegration and a rapid discharge without detriment.

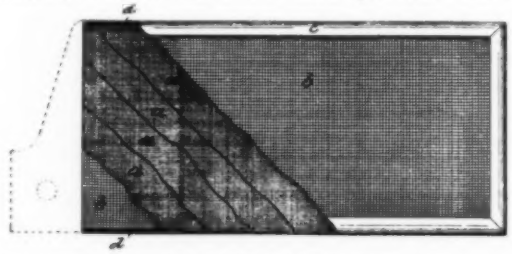


Fig. 4.—Storage Battery Plate.

Frame for Battery-Electrodes. Herbert Cottrell, Newark, N. J. Patent 722,946, March 17, 1903. Application filed September 13, 1902.

The object of the invention is to provide a frame for holding battery plates, probably of such character as described in the preceding patent. The claim reads: "A holder for electrode plates for reversible galvanic cells, comprising a frame of sheet material, doubled, to clip the electrode plates in its fold; and having a top extension, perforated to receive a bolt, whereby the frame may be clamped and from which it may be suspended."

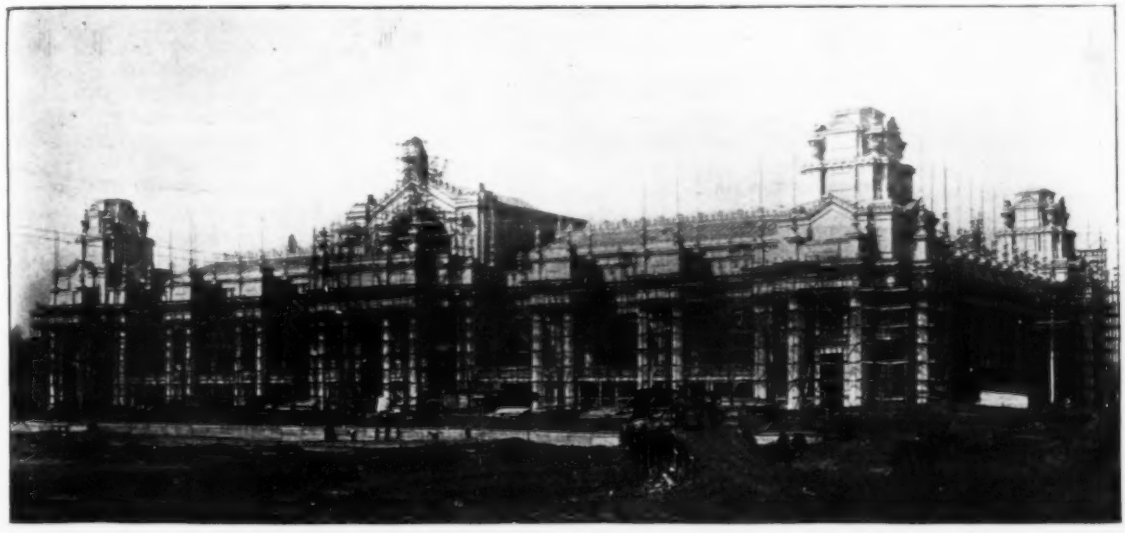
Galvanic Elements.

Galvanic Battery. M. M. Bair, Levallois-Perret, France. Patent 722,662, March 17, 1903. Application filed March 31, 1901.

This invention relates to galvanic cells or batteries of the kind that are hermetically sealed and intended for use in motor vehicles, and is particularly applicable to cells of the Leclanché type. The cell is provided with a detachable lid, to which the electrodes and the porous chamber may or may not be attached. The lid is so arranged that it can be secured to the outer vessel or to the outer vessel and porous chamber by means of resilient clamping frames, so as to maintain the lid hermetically in place and yet permit of its ready detachment.

THE DEPARTMENT OF ELECTRICITY OF THE ST. LOUIS EXPOSITION.

The Electricity Building of the Universal Exposition of 1904 is rapidly nearing completion. The accompanying views of this building are reproductions of photographs taken only in the last days of March and illustrate the marked progress which has been made within the last few months. By April 30th of this year—the date on which elaborate dedication exercises are to be held in St. Louis—the scaffolding will all have been removed and the building will stand complete, all but the sculptural decoration in the way of groups of statuary. The latter are to be very elaborate. A large group typifying electricity will surmount each of the corner pedestals, and smaller groups typifying the attributes of electricity, heat, light, power and speed, will be placed above the twin columns along the eastern facade, which borders on the Grand Basin and the Cascades. Statues of Franklin, Henry, Volta, Ohm, Ampère and Faraday will be placed opposite the principal entrances of the building and along the eastern front, each bearing an appropriate inscription.



ELECTRICITY BUILDING, ST. LOUIS EXPOSITION.

The Department of Electricity, with the co-operation of the Department of Mines and Metallurgy, is preparing for a most extensive exhibit of electrochemical and electrometallurgical progresses. For those exhibits, which from their nature do not admit of being placed within the exhibit palaces, there will be provided a special building having an area of 60,000 square feet, in which it will be possible to make any and all experimental demonstrations.

In industrial electrochemistry and electrometallurgy America stands already in the front rank; and to the European visitors the electrochemical exhibits will not be the least interesting.

The attitude of the Exposition authorities towards the electrochemical industries is certainly a most friendly and helpful one, and we trust that advantage of this will be taken by all in promoting a fine, historical, experimental and commercial exhibit in electrochemistry. We sincerely hope that all workers in the electrochemical field will give an united and hearty support to the Committee of the American Electrochemical Society, recently appointed to encourage and stimulate an interest in the electrochemical group of the Exposition.

CURRENT NOTES.

Biography of C. P. Steinmetz.—To the March issue of *Success*, Mr. Herbert Wallace contributes a very interesting and in some parts extremely amusing story of the early life of Mr. Charles Proteus Steinmetz, the famous electrician of the General Electrical Co., who, in a discussion of the (British) Institution of Electrical Engineers, was once called the "Maxwell of alternating current engineering"—a title which he fully deserves. The biographical sketch gives Mr. Steinmetz's life to the time when he came to the United States and found a position first as draughtsman with the Eickemeyer Co. and afterwards as the engineer in charge of the experimental work of the same company. Here the story stops, probably because the later life work of Mr. Steinmetz—beginning with his celebrated hysteresis researches in Eickemeyer's laboratory—is well known to every electrical engineer. The greatest part of the article is given in Mr. Steinmetz's own words, so that the sketch may be called an autobiography. It may be of special interest to our readers to learn that Mr. Steinmetz is greatly interested in chemistry, and at one time of his life intended to make his living as a chemist.

C. P. Steinmetz was born April 9, 1865, in Breslau, Germany. For twelve years he attended the gymnasium and afterwards for five years the university of the same city. As a boy at home, he had a small chemical laboratory, and used to spend a good deal of time in it. But his main interest centred in mathematics. "I want to say that absolutely all the success I have had has been due to my thorough study of mathematics.

"I went to the university to study mathematics and astronomy. It was somewhat before the time of electrical engineering. The arc and incandescent lamps did not exist, except, perhaps, as curiosities. Then I became interested in physical science, and studied physics, and, later on, natural history. It was some time before I began the study of electrical engineering, and then, strangely enough, it was chiefly because of my friendship for a fellow student who was pursuing that subject. When I commenced, I had no thought of making any practical application of it; I merely wanted to know something about the subject."

Mr. Steinmetz was twenty years old when he met his electrical engineer friend. It was through him, also, that he became connected with the Social Democratic party; and this connection was finally the reason why he left Germany. He had become the editor of a Socialist paper (a position for which he never received a cent), but, to divert the police, his friends got a Polish fish vendor to be recorded as the responsible editor. "Finally, the police confiscated the Socialist paper. They arrested the supposed editor, the Polish herring man, and wrote out a statement for him to sign, but he could

not write his own name. He and several others, among them my electrical engineer friend, were thrown into prison, and the Government officials were sure they had all the leaders, and that the movement had been effectually broken up."

The story how a regular secret correspondence was carried on between the prison and the outside world by means of letters written by simple chemicals, and later developed by chemical means, is very amusing. Later, however, the police began to become suspicious and were about to arrest Steinmetz. He preferred to leave Germany and went to Zurich, Switzerland.

"Before I left Germany, I had intended to become a chemist. Because I was a Socialist, I could not bring myself to accept a Government position, and I could not have earned a living at mathematics except in a Government position. Electrical engineering really did not then amount to anything in Germany, and chemistry seemed the only field in which I could make a good living. When I reached Switzerland, however, I decided to take up mechanical engineering. I knew much about a good many things, but nothing by which I could make a living. Obviously, my political career was ended.

"I had arrived in Zurich in June, 1888. I studied privately during the summer, and in the fall entered the Polytechnic School with an elective course, made up of mechanical engineering, turbine, steam engine, bridge construction, designing, etc. A friend and I lived together, and cooked our own meals. The following year, my friend's guardian directed him to go to America, and I decided to go with him.

"We sailed in the steerage on a French liner, paying 75 francs from Zurich to New York. I have crossed the ocean since, in the first cabin, but I have not had so pleasant a voyage since, as was that one in the steerage."

He succeeded in getting a position as draughtsman with the Eickemeyer Co. in Yonkers, at a salary of $12 a week. "My friend also succeeded in getting a place, and we took up our former housekeeping plan together, in a room in New York City. I had to get up very early, prepare breakfast, and go to Yonkers. Our plan worked very well, with but one drawback. We could never agree as to who should wash the dishes." (There is an unauthorized story, not mentioned in the article, stating that they would wait till they had company and then would have their friends do the dishwashing.) "We were both good cooks, and managed to live cheaply and well. but, after a year of this life, my friend had his fiancee come from Germany, and they were married. Then I moved to Yonkers, to be nearer my work."

His knowledge of chemistry was of advantage to him, to be graduated from draughting. "It was a very simple thing. One day Mr. Eichemeyer happened to come into the room where we were working, and he was in a great rage because he had stained his fingers with aniline ink and could not get it off. I told him to use a certain acid, diluted, and the ink would come off at once. The result was as I said, and he was so pleased that afterwards he invited me into his office, and we gradually became acquainted. I was able to be of some assistance to him, so he raised my salary and kept me working more with him. He put me in charge of all new and experimental work, and I had to look after the men, make patent drawings, and see that everything was properly done at the factory. I studied every night until after midnight, and, during the first two or three years there, I wrote a number of scientific papers." The article is illustrated by the very characteristic reproduction of a photograph of Mr. Steinmetz.

Book Reviews.

Elektro-Metallurgie: Die Gewinnung der Metalle unter Vermittelung des Elektrischen Stromes. By Dr. W. Borchers. Third edition, enlarged and entirely revised. Leipzig, 1902. Erste Abtheilung. Pages, 288. Price, 9 Marks.

This first part of the third edition of Dr. Borchers' well-known work will be doubtless accorded a favorable reception because of the excellence of the previous editions and the reputation of the author. The author takes for granted the reader's familiarity with the nomenclature, laws and paraphernalia of electrochemistry, and plunges at once, *in medias res*, by commencing on page 1 with the metallurgy of magnesium. This is followed by lithium, sodium, potassium, calcium, strontium, barium, beryllium, aluminium, the cerium metals, copper, and part of the treatment of nickel.

The omission of the introduction, giving a resume of electrometallurgical principles, is doubtless due to the appearance in recent years of so many treatises on the fundamentals of electrochemistry, that the author considered even the briefest introduction superfluous. Its entire omission has, however, given an air of incompleteness to the work, for which no degree of excellence in the subject matter presented can completely atone.

The electrometallurgy of magnesium occupies 20 pages, and is more complete in its details of actual work than any other treatise we have seen. In this essay we find all the practical directions for making the metal most carefully given. One error is the statement that magnesium occurs as silicate "always in combination with other silicates," whereas three of the four minerals named thereafter are simple silicates of magnesium alone—serpentine, talc, meerschaum. In stating that magnesium is used as a refining agent for German silver and steel, the reader should at the same time be advised that there is considerable danger of explosion in so using it, if care is not taken.

In the 42 pages devoted to sodium, almost all the possible and impossible schemes for obtaining the metal are described, but one of the best ways of obtaining sodium from salt, the Acker process of producing sodium-lead alloy, is not mentioned, although it was described in print early in 1902. The process by which the larger part of the metallic sodium at present manufactured is made, the Castner process, is treated altogether too briefly, a description of the apparatus being given, but no mention made of the fact which is the kernel of Castner's process, viz., that the caustic must be electrolyzed *within 25° of its melting point*, in order to get any metal. If Dr. Borchers has been compelled to condense, because of the great extent of the field he attempts to cover, there are a hundred things given regarding sodium, any one of which should have been omitted to make room for this description of the basic principle of the Castner process.

In the 70 pages given to aluminium, Dr. Borchers sees the Héroult and Hall processes in a much better light than in his previous editions. His presentation is much fairer than before, and by the time that a fourth edition of this work is prepared for the press there is a reasonable hope that Dr. Borchers will have entirely straightened out the relation of these processes to each other and to the previous state of the industry. He places the Minet process where it rightly belongs, as an inoperative process, and even abates some of the extravagant claims made in a previous edition for the experiments of one Dr. Borchers.

The treatment of copper is full and satisfactory, but not quite up to date as regards American practice. The current density used, the method of continuously purifying the bath, the mechanical auxiliaries of our plants and the operating costs, are a little behind what they should be given in a book finished in October, 1902. The information is at least one year in arrears of that date, at least as far as America is concerned; but what is given is accurate and clear, as far as it goes.

Altogether, the book is very readable, the cuts are of that high excellence which accompanies all of Dr. Borchers' publications, the arrangement is clear, the tone is less caustic and more judicial than marked the earlier editions, but we feel a little disappointed at the omissions. Dr. Borchers has done very well—we had expected that he would have done a little better.

HANDBUCH DER ELEKTROCHEMIE: SPECIELLE ELEKTROCHEMIE. By Dr. H. Danneel, Aachen. Lieferung I. Halle: Wilhelm Knapp. Price, 3 marks.

The present volume is the first instalment of a large Handbook of Electrochemistry, which will be published by Wilhelm Knapp. The character of the work will best be shown by a list of the subjects, which will be included. These are the following: Theoretical Electrochemistry, by Prof. Dr. W. Nernst, Göttingen; Electrical Measurements, by Dr. E. Bose, Göttingen; Special Electrochemistry, by Dr. H. Danneel, Aachen; Elements and Storage Batteries, by Prof. Dr. K. Elbs, Giessen; Electroanalysis, by Prof. Dr. F. Küster, Clausthal; Electromagnetic Ore Dressing, by F. Langguth, mining engineer, Mechernich; Technical Inorganic Electrochemistry, by Prof. Dr. W. Borchers, Aachen; Technical Organic Electrochemistry, by Prof. Dr. K. Elbs, Giessen; Electroplating, by Dr. H. Stockmeier, Nurnberg. The parts treating about electrical measurements, electromagnetic ore dressing and electroplating will be issued complete, while the other parts will be published in instalments, the price of each instalment being set at 3 marks. The volumes and single parts can also be bought separately.

The publication of the whole work is expected to be finished in about two years. The aim of the book is to give full and complete information about every electrochemical reaction known up to the present time, its origin, its theory and application. Electrical measurements and electromagnetic ore dressing are included in order to give as complete a review as possible of all branches of science, touching the domain of electrochemistry. The firm of Wilhelm Knapp, which have for a number of years been well and favorably known by the books they have brought out on electrochemical subjects, are to be congratulated on their enterprise in bringing out an encyclopedic work, of the scope proposed. The list of the authors of the various parts, containing, as it does, names well known in electrochemical circles, give good reason to expect that the treatment of the subjects will be thorough and up to date. There is no need to dilate upon the want existing for such a hand-book, in which the information, which is at present widely scattered through a number of journals and patents, will be grouped together in comprehensive form. That such a want does exist is apparent to everyone interested in the subject, and the book will therefore be welcomed by the electrochemical public.

The part on "Special Electrochemistry," of which the present volume is the first instalment, will be complete in about 14 instalments. It is stated, that besides the compilation of the anorganic electrochemical reactions, which have become known up to the present, and a collection of the literature appertaining to them, there shall be collected data and literature about conductivity, polarization and changes of free energy in reactions (electromotive forces and single potentials). Part I bears the title: "Special electrochemistry of the elements and anorganic compounds. Their preparation by electrochemical means and their electrolysis." The volume under consideration is devoted to the treatment of hydrogen, water, hydrogen peroxide and various acids, chief among which are hydrochloric, sulphuric, persulphuric and nitric acids. These are taken up in their historical development, and a large number of literature and patent references are given. Their formation by means of electrolysis and their decomposition by the current is described in detail.

HANDBUCH DER ELEKTROCHEMIE: ELECTROMAGNETISCHE AUFBEREITUNG. By Victor Langguth, mining engineer. Mechernich: Wilhelm Knapp. 64 pages. Price, 3 marks.

This part of the German Hand-book of Electrochemistry is a comparatively short one. The author treats the subject in the following divisions: Development and importance of electromagnetic ore dressing; principles of electromagnetic separation; electromagnetic separators, (1) with movable magnets, (2) with fixed magnets; results obtained by electromagnetic ore dressing. The author has had considerable experience with magnetic separators, in his connection with the Mechernich Bergwerks-Actienverein, the constructors of the Mechernich type of separators and has treated the subject in a clear and concise style. As the book only comprises 64 pages, it is evident that the discussion of the various types of separators had of necessity to be cut short. It is to be regretted that the book has not been expanded to twice or three times its size, and that not more practical data have been included as to the detailed construction of the various types, their capacity, price and results in practice. The growing importance of the subject would certainly have warranted such a treatment. The author being an interested party and apparently favoring the separators constructed by the Mechernich Bergwerks-Actienverein, has yet endeavored to treat the other systems from an impartial standpoint. He reaches the following conclusion on page 49: "For the separation of feeblymagnetic bodies we have the systems of the Mechernich Bergkerks-Actienverein and of the Metallurgische Gesellschaft, as owner of the Wetherill patent. The working of the separators is so different, as are also the difficulties which had to be overcome in the two systems, that only the comparison of results obtained on a large scale by the latest constructions of both companies, can furnish a definite basis as to the superiority of the one or the other."

AMERICAN AUTOMOBILE BATTERIES.—II.

(*Continued from page 151.*)

THE MADIGIN BATTERY.

This battery is only manufactured at present in Canada, although large quantities are being exported to the United States and foreign countries notwithstanding the heavy tariff duties on this class of goods. It is manufactured there under Madigin patents by the Croftan Storage Battery Co., Toronto, Canada, which are the only firm manufacturing storage batteries in the Dominion of Canada.

The construction of the plate in this battery is shown by figures No. 1 and No. 2. Figure No. 1 shows the grid, which, as will be noticed, is made of one thin piece of sheet lead $\frac{1}{32}$ inch thick. This sheet is highly perforated with over 11,000 holes to the square foot, and is horizontally corrugated so as to present parallel ridges about $\frac{1}{8}$ inch apart. The positive plates are corrugated to such a depth as to render the plate $\frac{1}{8}$ inch thick when finished, and the negative plate $\frac{3}{32}$ inch thick. In the process of manufacture a rim and lug are burned on at the operation so as to form a border of $\frac{3}{16}$ inch all around the plate. Fig. 2 shows a positive plate fully pasted and formed, and, as will be noticed, the grid is almost entirely covered by the active material, with the exception of the small protuberances of the corrugations which present themselves on the outside surface of the plate. In this manner the grid in itself is almost entirely protected from dangerous electrolytic action, which always causes rapid depreciation and disintegration.

The positive grid of their standard automobile type weighs but 10 oz., and when pasted and fully formed will give a discharge of 24 ampère hours at a five-hour rate. The positive plates before pasting are coated with a thin coherent layer of lead peroxide by electrolysis, and are then removed from the solution and pasted with usual oxides, with the addition of a chemical (the nature of which they withhold), which renders the active material extremely hard and yet highly porous. After pasting the plates are subjected to the regular forming process.

In assembling the elements the positive plates are enveloped with a layer of pure fibrous cellulose, which is chemically treated so as to render it neutral and at the same time to guard against disintegration. The plates are then packed closely together, with the cellulose envelope separating each, and are then connected or burned together in the usual manner.

It will thus be seen that this method of insulation gives a complete perfectly-porous insulating wall between the plates, and if the cell is only half full of electrolyte (which often happens when batteries do not receive proper attention) the entire surface of the plates will remain in action, owing to the juxtaposition of the insulating material and the capillary attraction resulting in the use of this method of insulation. It also prevents any active material from possibly becoming dis-

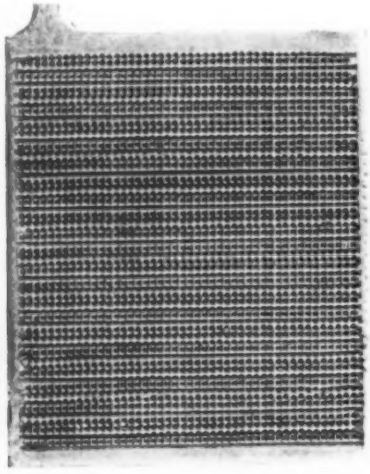


FIG. 1.—GRID UNFORMED.

engaged from the grid, and, furthermore, eliminates all washing action of the electrolyte on the plates, which has heretofore been one of the greatest difficulties to be contended with in automobile practice, owing to the usual excessive vibration while in operation.

From the construction employed it must be noticed that notwithstanding the extreme lightness, as well as the extraordinary elasticity which has been attained, durability has not been sacrificed, but on the contrary is always in evidence. The battery requires but a small portion of the space usually demanded by storage batteries, owing to the compact nature

FIG. 2.—GRID FORMED.

of the elements and the small but sufficient quantity of the electrolyte employed. As an illustration, their 13-plate cell occupies but a space of 2⅝ inches x 6¼ inches x 9 inches high and weighs but 18 pounds. This cell has a capacity of 132 ampère hours when discharged at the unusually high rate of 35 ampères. This feature is due very much to the perfect contact of the active material with the grid, as well as the extremely low resistance of the grid itself, which admits of discharges much higher than this amount without depreciation. The practice, however, which they employ is to furnish batteries of such capacity as to give from six to eight hours' operation at normal load. In this manner a mileage of 80 miles per charge is easily secured by ordinary vehicles with a battery weighing less than has usually been employed.

This firm also manufactures a patent removable and non-

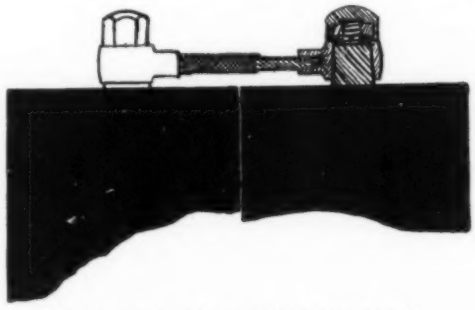


FIG. 3.—FLEXIBLE REMOVABLE CONNECTION.

corrodible connection for automobile batteries, which is flexible and has a large number of advantages over the usual method. By its adoption any cell or set of cells may be removed or replaced instantly without the necessity of sending the entire set of batteries to the factory to be welded together. This is a valuable feature, when batteries are required to be washed at regular intervals. Fig. 3 shows a cut of this connection as applied to two cells, and also shows its construction. It is manufactured in sizes adaptable for all existing American batteries.

Clare Storage Battery.

The special feature of the Clare battery, built by the Consolidated Storage Batteries Co., of New Jersey, is the use of earthenware receptacles for holding the active material, constructed as follows: Plates are made of earthenware, of sufficient porosity to allow the electrolyte to pass freely through them, and at the same time free from impurities, which would make the substance a conductor.

Each plate is divided on one side into many small, square windows by narrow ribs, the active material being pressed into these windows; the other side of each plate has parallel ribs in one direction only. Each plate also has a heavy rib on one or two of its edges, extending slightly further from the plate than the smaller ribs which form the windows containing the active material.

When two such plates are put together, so that the windows face each other, there is thus a small space left between them opposite windows, and into this space a thin sheet of pure rolled lead, about 1-32 inch in thickness, is forced, so that it comes into intimate contact with the active material in each window. This sheet of lead serves only for collecting the current from the active material, and not as support.

The heavy ribs at the edges of the plates are cemented together by an acid-proof cement. A pair of such earthenware plates, joined together in this way, forms a receptacle of rigid structure, which represents a single positive or negative element of a battery

The principal advantages claimed for this construction are lightness and durability of the plates, with sufficient porosity to allow the electrolyte to pass freely through the sides of the receptacles; the internal resistance is very low, and the active material is so firmly held in the receptacles that it cannot fall out. The receptacles are also sufficiently elastic to allow for all expansion of the active material.

Concerning weight and capacity, the manufacturers state that their batteries made for automobile work give 5 ampère hours per pound of cell complete.

SLATE FOR ELECTROCHEMICAL USES.

The value of slate as a material for resisting certain chemicals has long been recognized by manufacturers. In the preparation of bleaching powder from chlorine procured by the Deacon process, large quantities of slate are used in the construction of the bleach chambers. Lime is spread on slate shelves, and the chlorine caused to pass over them.

With the advent of electrolytic processes for the treatment of brines, slate was soon found to be a most admirable material. Its chemical composition is such that alkaline solutions and bleach liquors have almost no action on it. Hence it has been extensively applied to the cells used in the manufacture of chlorine and caustic soda. Especially to that class of cell known as the diaphragm type.

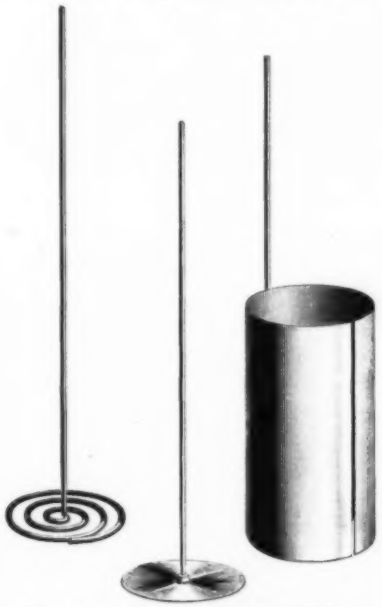
In these cells it has been found satisfactory as a material for constructing the tanks, as a covering for the gas space, and as a support for the electrodes.

A slate to fulfill the requirements of this work must be free from mineral veins, soft enough to permit ready working, and at the same time possess sufficient resistive properties to enable it to withstand the action of alkaline brine solutions. Obviously it should be free from check cracks.

The slate quarried by the American Slate Co., of Boston, Mass., has been found to fill these requirements in a most satisfactory manner. Cases have been observed where this slate has been immersed continuously in electrolytic baths for years without showing signs of deterioration, except for a slight discoloration. This fact, together with its resistance to attack by chlorine is sufficient to explain the marked favor with which it is regarded by the manufacturers using the recently developed electrolytic processes.

PLATINUM ELECTRODES.

Messrs. Baker & Co., the platinum refining firm of Newark, N. J., report a constant increase in the demand for various forms of platinum apparatus made by them for electrolytic purposes. Fig. 1 to 8 show various forms of platinum electrodes for electrolytic separations. Electrodes, 1, 2 and 5 are furnished in sizes of 5 grams weight each and upwards; the



FIGS. 1, 2, 3.—PLATINUM ELECTRODES.

standard form of electrode, Fig. 1, has a spiral 7/8 inch in diameter. Fig. 3 and 4 represent electrodes in the form of a closed and an open cylinder, respectively, of an approximate weight of 8 grams each and upward; the standard size is 1 inch in diameter, 2 inches high, the weight being 11 grams. Fig. 6 to 8 show electrodes of a weight ranging from 20 to 50 grams. In addition to these and other simple forms of platinum electrodes for laboratory separations, Messrs. Baker

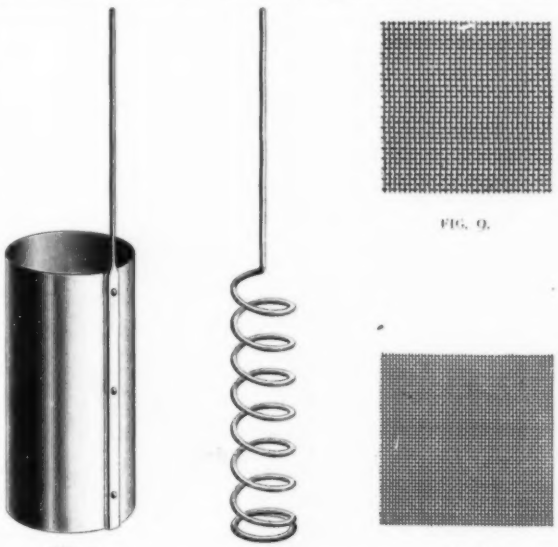
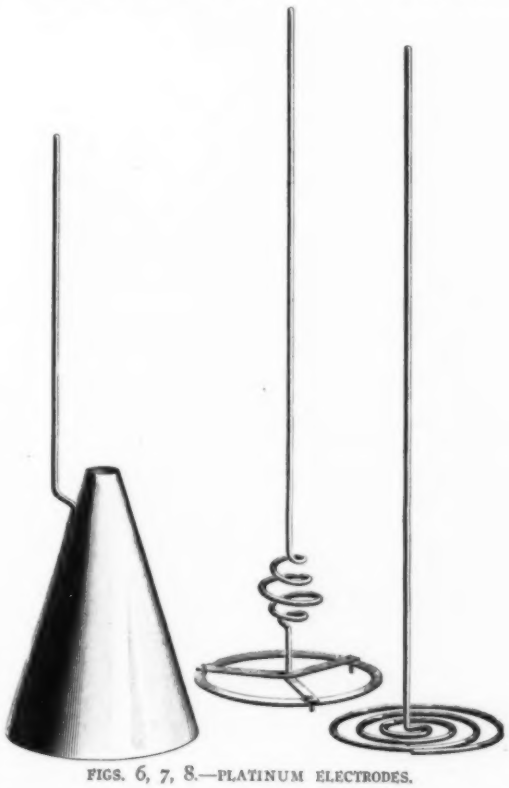


FIG. 4. FIG. 5. FIG. 9. FIG. 10.

PLATINUM ELECTRODES.

& Co. build to specifications all sizes and shapes adapted to individual requirements.

The present tendency to use platinum-gauze electrodes, both for laboratory and commercial separation, is rapidly growing



FIGS. 6, 7, 8.—PLATINUM ELECTRODES.

in favor, because of the many advantages they offer over the solid sheet type. Greater uniformity of current density per unit of surface, and hence less variation in depth of deposit

are obtained with gauze electrodes. Free escape of disengaged gases and deposit of the metal completely encircling the individual wires of the mesh practically prevent peeling losses. Finally, greater current density can be employed, thus reducing the time required for effecting separation. Such platinum-gauze electrodes are represented in Fig. 9 and 10. The two standard sizes, kept in stock by Messrs. Baker & Co. are 45 mesh, 0.0085-inch wire, weight per square inch 1,500 grams, and 52 mesh, 0.004 inch wire, weight per square inch 0.543 gram.

GENERATORS FOR ELECTROPLATING, ELECTROTYPING AND OTHER ELECTROLYTIC WORK.

In our September issue we gave an illustrated description of several modern types of Eddy electroplating dynamos. In the following we will give some supplementary information on these Eddy machines which are now made by the General Electric Co.

These, machines, as now manufactured, run at low speeds, are cool under continuous operation at full load, and are little effected by change of load in the baths. No change in lead of the brushes is required for variation in load. The standard generators for electroplating and electrotyping are built in six sizes. The smaller sizes have a frame consisting of a rectangular steel casting to which are bolted two steel poles. The larger sizes are of the multipolar type. The frames are of cast steel made in one piece, to which are bolted cast-steel pole pieces.

The multipolar type is well adapted for the larger sizes, where the brush contact is necessarily large in order to collect the heavy current with a minimum of heating and loss in resistance. The shaft between the bearings is short and of sufficient size to entirely eliminate springing when subjected to the sudden overloads which very often occur when the machine is accidentally short-circuited at the tanks.

The pole pieces are of such a shape as to minimize the magnetizing energy required in the field coils to produce a powerful field of force. The section under the coil is small in comparison with the area exposed at the air gap, and the projecting pole tips are so proportioned that a conductor of the armature enters a field of gradually increasing density rather than one in which the change is abrupt at the pole corners. This feature of the design prevents polar heating, eliminates the disagreeable magnetic hum so often experienced, and forms a fringe of magnetic lines in the neutral point for the reversal of the current under commutation.

The field coils are wound on forms, thoroughly insulated, taped and baked. They can be easily and quickly removed from the poles in case of accident.

The commutators are built up of copper strips, insulated from each other by mica, and are so constructed that it is impossible for the strips to become loose and cause the brushes to jump, a condition which necessarily produces sparking and its consequent wear of commutator and brushes. On the larger sizes, openings in the heads, and air passages in the armature core allow a free circulation of air through the commutator and armature.

The tangent type brush-holders firmly clamp the brushes and insure good contact. The brushes are of woven wire, which is superior for conveying the heavy current at a low voltage with a minimum loss in resistance. They greatly reduce the wear of the commutator by retaining lubrication, and require very little attention. The brushes on all the machines are of sufficient size and number to carry the full current with little rise in temperature above that of the surrounding air. This is an essential feature, since less attention is required to keep the commutator and brushes from wearing, when the oil does not become overheated, so as to lose its lubricating properties. The adjustment of the brushes is very simple and can be quickly accomplished.

The armature core is made up of sheets of best annealed iron, and is firmly held in place by iron heads. Air ducts lead from the centre of the core to the circumference, providing thorough ventilation for all parts. The bar-wound type of armature which is used is well adapted for this class of machinery and forms a practically indestructible winding. It reduces the danger of burn-outs caused by accidentally overloading the machine, and is not likely to be injured by rough handling. The winding, which is heavily insulated, and connected at the ends by copper ribbons, is inserted in an insulated slot cut in the core, and is entirely below the surface. In case of accident to one or more bars they can be easily removed without disturbing the remainder of the winding. All connections between the armature winding and the commutator are soldered. When screws or bolts are used they are liable to become loose or corroded, thus increasing the resistance of the armature, and causing sparking between the commutator and brushes.

The voltage of both self-excited and separately-excited machines is regulated by a rheostat in the field circuit, which is intended to keep the voltage constant for all changes in load, but will not reduce the voltage more than 25 per cent. from the maximum rating.

In the larger machines the load sometimes varies between wide limits, owing to the introduction or removal of work at the tank. With a self-excited machine this would require constant manipulation of the rheostat to keep the voltage constant, while with a separately-excited machine the voltage will remain practically the same. With the larger sizes, therefore, a separate generator to excite the fields of the machine is furnished. If, however, a continuous current line of any of the standard voltages is available the fields of the machine may be excited from this line, and no exciter will then be required.

ELECTROPLATING DYNAMO.

So-called double-voltage machines are made with two commutators, one at each end of the armature. The armature has two distinct windings each connected to its own commutator, and by proper connection at the terminals the voltage of the output will be equal to the sum of the voltages of the two commutators, and the current that given by one; or the voltage may be made that of a single commutator, and the current that given by two. For example, with a machine having a voltage of 5 and a current of 1,200 ampères, by a different connection a voltage of 10 and a current of 600 ampères can be obtained without change of speed. When both voltages are required at the same time the machine will take the place of two separate machines, and use only about one-half the amount of copper in the line. The total current used with the high voltage, plus one-half the total current used with the low voltage, should not exceed one-half the maximum current of the machine. For example, suppose a machine to have a maximum output of 1,200 ampères at 5 volts; it would be possible when connected on a three-wire system to draw a current of 1,000 ampères at 5 volts, and another of 100 ampères at 10 volts.

The three-wire system of distribution when used with these machines effects a very large saving of copper, and a marked improvement of voltage at the tanks when work is introduced or removed.

The accompanying illustrations represents a double-voltage machine, giving 600 or 300 ampères at 5 or 10 volts respectively, when running at a speed of 650 revolutions. The power required for driving it is 6 horse-power.

POTTERY WARE FOR ELECTROCHEMICAL PURPOSES.

In almost all electrochemical work, not only in experimental laboratories, but also in work which is done on a commercial scale, one of the most indispensable requirements is reliable material in the way of chemical pottery ware. For the past twenty-five years the Charles Graham Chemical Pottery Works, of Brooklyn, N. Y., have been turning out this class of material; in fact the entire plant is devoted solely to the manufacture of this line of chemical apparatus.

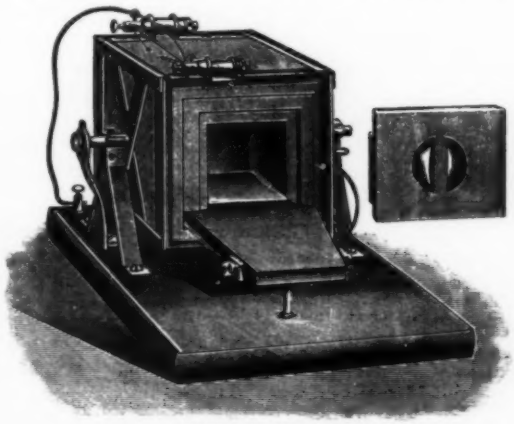
The illustrated catalogue recently sent us by Mr. Charles Graham, gives a great number of pottery apparatus of various forms and for various purposes, such as pots and tanks, acid towers, distilling apparatus, stoneware coils, retorts and condensing worms, chlorine apparatus, water lute receivers and connecting pipes, faucets, spigots, and valves, all kinds of jars, pitchers, dishes, etc.

This firm also makes acid-proof vessels to the size of 500 gallons, and any kind of vitrified stoneware chemical apparatus, such as receivers, arms, connecting pipes, crystalizing and evaporating dishes, acid pitchers, funnels, glazed acid bricks, carbon stoppers, etc.

Mr. Charles Graham also manufactures special apparatus to order. Several pumps made by him for the Canadian Copper Co. were described in the interesting paper of Mr. David H. Browne, read at the Niagara Falls meeting of the American Electrochemical Society. They are of a very compact form. An illustration of this type of pumps may be found on page 231 of Vol. II, of the Transactions of the American Electrochemical Society.

ELECTRIC FURNACES, PLATINUM WARE AND FUSED QUARTZ APPARATUS.

The firm of Messrs. Eimer & Amend, of New York City, report that they have recently made important progress in the construction of electric furnaces, both for direct and alternating current. The most improved recent forms, one of



ELECTRIC FURNACE.

which is shown in the adjoining illustration, will be shown and described by Mr. A. Eimer, of Messrs. Eimer & Amend, at the coming New York convention of the American Electrochemical Society.

Messrs. Eimer & Amend are also manufacturers as well as importers of balances of the finest quality, especially for electrochemical work. They are also very large dealers of platinum ware in various forms and makes, including United States Mint parting apparatus. They have large facilities for making platinum electrodes and platinum vessels of every design. As something new, they refer to their new platinum-carbon determination apparatus, and also to the carbon determination apparatus, with electric ignition arrangement, with no platinum metal used. They also keep an extensive stock of electric outfits for stirring machines, centrifuges, etc.

Among the most interesting exhibits which will be shown to the members of the American Electrochemical Society, there will be various quartz ware, such as crucibles, flasks, tubes, test tubes, breakers, dishes, thermometers, etc. Quartz is known to be among the best insulators and withstands at the same time extremely large changes of temperatures. One of the simplest and most convincing experiments is to heat a small flask of fused quartz to white heat and then pour water into the white, hot vessel, without the least harm being done to the vessel. Another property of this fused quartz is that it is not hydroscopical, and that it is not attacked by many important chemical reagents, which is of great importance for many purposes. These quartz apparatus will be of special interest, in view of Mr. R. S. Hutton's paper, read at the Niagara Falls meeting of the American Electrochemical Society on the fusion of quartz.

A special visit of the members of the American Electrochemical Society to the show rooms of Messrs. Eimer & Amend have been arranged for the Thursday afternoon, April 16th.

THE ELECTROLYTIC DECOMPOSITION OF WATER AND ITS APPLICATIONS IN INSTALLING STORAGE BATTERIES.

In recent years the use of the oxyhydrogen flame has been widely introduced into practice for various purposes for which formerly hydrogen, generated by the action of sulphuric acid upon zinc, together with compressed air had been generally used. The main advantages are: first, the higher temperature of the oxygen hydrogen flame, which enables one to finish a given work in a shorter time, and, second, the great convenience of electrochemical methods for generating the oxygen and hydrogen required for the oxyhydrogen flame. Especially for installing storage batteries the oxyhydrogen flame has great advantages in assembling plates together, and joining the edges of the lead lining in tanks, or in general for making any lead joints or connections.

The use of compressed oxygen and hydrogen is to be recommended wherever relatively small quantities of the gases are used at one place. On the other hand, if at one place the oxyhydrogen flame is to be used continually, every day, it would be uneconomical to pay for the compressions of the gases, the tanks and the freight, and it is much cheaper to install an electrolytic water decomposition plant.

When water, in which an acid or an alkaline is dissolved, is decomposed by the electric current, one ampère hour produces theoretically 0.0376 grams of hydrogen and 0.298 grams of oxygen, or 418 c c of hydrogen and 209 c c of oxygen (under atmospheric pressure). The only difficulty in the construction of the electrolytic decomposition plant is to prevent the danger of explosions due to the mixing of the two gases, oxygen and hydrogen.

In the following we give a description of the Schoop system, as installed by the Koelner Akkumulatoren-Werke, Gottfried Hagen, Kalk, near Cologne, Germany. The characteristic feature of this system is that the electrodes are made in the form of tubes, the outside of which is coated with a layer of insulating material. These tubes are placed side by side in the electrolyte, and as only their inside surface is conducting, the development of gases can only take place in the inside of the tubes. The use of tubes has the further advantage that their

length may be so adjusted that the gases escape from the tubes directly under the pressure which is wanted—in general that of column of water of 60 to 70 cm height—so that no artificial compression of the gases is required.

These tubes may be made of iron for an alkaline electrolyte, and of lead for an acid electrolyte; but in practice it has been found that an acid electrolyte is greatly preferable. In the Schoop system pure sulphuric acid of a specific gravity of 1.23 is used.

Each electrode consists of three parts; a larger one of the form of a globe in which the current passes into the acid; a lead body of large surface which is placed inside of the globe and serves the only purpose of increasing the acting surface; and a tube at the top of globe which serves as electric connection for the globe, and at the same time as exit tube for the developed gases. The length of the tube depends upon the pressure under which the gases are to be developed. For such a tube with a globe of about 90 mm diameter a current of 25 ampères may be continually used, so that per hour 10.44 liters of hydrogen and 5.22 liters of oxygen are generated. The tubes are placed in a box, the inside of which is coated with lead; a series of positive tubes is always placed at the side of a series of negative tubes. Below the tubes there is a space for collecting the fine powder of lead peroxide which drops down from the positive electrodes.

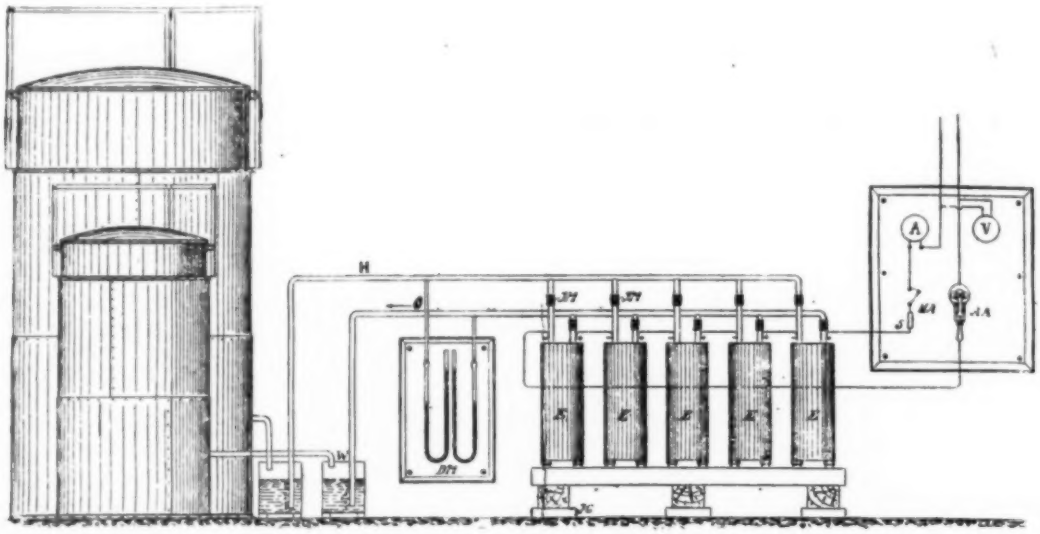
The apparatus is shown in the adjoining diagram in which E is the electrolyzer, A an ammeter, V a voltmeter, H A a hand switch, A A an automatic circuit breaker, B a fuse, I M an insulating joint, and D M a device for measuring the pressure.

The apparatus requires no attendance, with the only exception of distilled water being filled into the apparatus about once a week. The voltage of operation is about 3.3 to 3.6 volts per cell, according to the current density used and the temperature of the electrolyte. In connection with a 110 volt installation about 30 electrolyzers are connected in series, the gas exit tubes of the different cells being connected with the tubes for collecting the gases by means of insulating rubber tubes.

An installation of this kind has been in continuous use since January, 1902, giving per electric horse-power 97.5 liters of hydrogen and 48.75 liters of oxygen, *i. e.*, one cubic meter of the mixed gases requires 6.8 horse-power hours. With warm acid this energy consumption is reduced to 6.2 horse-power hours. If the cost of one horse-power hour is assumed to be 1 cent, the cubic meter of the mixed gases costs 4.2 to 4.8 cents.

The purity of the gases is great; oxygen is guaranteed to contain 99 per cent. of oxygen and contains much ozone when freshly developed; the balance of 1 per cent. is steam. The hydrogen is guaranteed to contain 97.5 to 98 per cent. of hydrogen. If for therapeutic purposes the oxygen must be free of steam, is only necessary to let the oxygen pass through concentrated sulphuric acid.

The advantages of the system are stated to be the following: absolute safety of operation and prevention of explosions; if the electrical connections are made correctly, there are no interruptions of service or repairs, as diaphragms of asbestos, etc., are not used; the gases are nearly chemically pure; the attendant has to do nothing but to fill in pure water at intervals. A small disadvantage of the system is the use of more electrical energy than in other systems, as there is a counter e m f in the apparatus, which behaves like a charged storage battery of small capacity.



WATER DECOMPOSITION PLANT.

Personal.

Dr. Walther Nernst, the distinguished professor of electrochemistry at the University of Goettingen, Germany, and the inventor of the Nernst lamp, will participate in the proceedings of the American Electrochemical Society, as already noted in our last issue. Dr. Nernst is due to arrive in New York City about April 3d, from Europe.

The well-known electrometallurgist, Mr. Titus Ulke, has accepted the position of assistant to the manager of the Clarion and Highland Mills of the New York and Pennsylvania Co. This note is here repeated in order to correct a typographical error in our last issue.

Assistant Professors Dr. W. D. Bancroft and Dr. F. Merritt have been promoted to full professorships of physical chemistry and physics, respectively, in Cornell University.

Mr. G. D. Case has resigned as superintendent of the Washoe smelters of the Amalgamated Copper Co. at Anaconda, Mont., and has accepted a similar position with the Copper Range Co., near Houghton, Mich.

Mr. Hugh Rodman, of the Electric Storage Battery Co., is spending a month in Orlando, Ky.

The Boston Society of Civil Engineers has elected Prof. Ira N. Hollis as president. Prof. Hollis holds the chair of engineering at Harvard University.

Mr. J. Parke Channing is in the City of Mexico.

INDUSTRIAL NOTES.

THE METALS RECOVERY CO. have recently been organized in Philadelphia, with a share capital of $1,250,000, consisting of $250,000 in 7 per cent. preferred and $1,000,000 common stock. The president of the company is Dr. N. S. Keith, of New York City, who has transferred to the company his patents 597,820, of January 25, 1898, for an electrolytic gold and silver process; 700,941 of May 27, 1902, for an electrolytic copper process, and 714,914 of December 2, 1902, for a new process of winning metals from their ores. The latter process which is not electrochemical, shall be employed at the first reduction works of the company, to be erected at High Hill, Virginia district, Va., at the mines of the Virginia Copper Co. The process of Dr. Keith consists in grinding the ores and their gangues to the necessary degree of fineness, and after mixing the ground materials with comminuted carbon—such as ground coal, ground charcoal, or petroleum—he heats them in a suitable furnace to the degree of fusion of the particles of ores. The resulting metallic substances which have a more or less globular shape, are separated from gangues by any suitable method of concentration; on account of their globular shape they are more readily and effectively separated from the gangues by concentration. In the prospectus of the company it is estimated that the cost of operation per ton of copper ore (including crushing, mixing, furnace operation, concentrating, and putting the metal into bars) is $1.50 at High Hill, Va.; the copper ore at this place contains 5 per cent. of copper, so that one ton of ore yields 90 pounds of copper, which the Virginia Copper Co. agrees to buy at the rate of 6 cents per pound, *i. e.*, $5.40. The cost of operation is stated in the prospectus to vary between $1 and $1.50 in Virginia, and from this figure to $2.50 per ton in Arizona, depending entirely on the cost of coal, power and labor.

THE ELECTRIC STORAGE BATTERY CO., Philadelphia, Pa., have recently closed several large contracts for the installation of storage batteries in connection with street railway work on the Pacific Coast. The Los Angeles Railway Co. have contracted for three batteries, two consisting of 264 cells having a capacity of 1,000 ampères and one of 264 cells having a capacity of 2,000 ampères. The Pacific Electric Railroad have also contracted for a battery of "chloride accumulators," consisting of 264 elements of 1,000 ampéres capacity. Several batteries are now in process of installation for the following roads in the same section: The Oakland Transit Consolidated, the Los Angeles Pacific Railway and the North Shore Railroad.

ELECTRIC STORAGE BATTERY LOCOMOTIVES.—The C. W. Hunt Co., West New Brighton, L. I., N. Y., have recently issued a small booklet on storage battery locomotives for use in shops, foundries and factories. Their general construction is described and illustrated, and their advantages are pointed out. While the great weight of lead batteries in proportion to the energy stored by them precludes their use for long hauls or high speeds; but for shop or yard work the increased weight from the batteries is an advantage in giving a great draw-bar pull. On tracks substantially level, or with grades frequently found in manufacturing establishments, a battery is a most convenient, economical, and efficient source of power. In almost all cases the first cost of the battery is less than the cost of trolley wires and supports, including cost of erection, if the trolley system were used; and the expense for maintenance is far less than for trolley wires. Furthermore, there are the very important advantages that a battery locomotive can instantly run on any track, regular or improvised, while the trolley locomotive can run only where wires are installed; trolley wires cannot well be run in erecting shops, machine shops, or under over-head cranes, while the battery locomotive is operative wherever a track is laid. The current from the battery is utilized by various combinations of series parallel connections, thus obtaining the different variations of draw-bar pull and speed required for general shop work. Unusually large and heavy battery plates are used, which are not overworked even in starting the load, thus insuring a durability and efficiency of the lead plates equal to that found in stationary batteries in lighting plants. The booklet states that "batteries for automobile work are usually required to deliver about 7 watts per pound of lead, while the locomotive batteries are called upon for only 2 watts per pound." Two independent electric motors are used, connected at will, either in series or in parallel. In another illustrated pamphlet of the C. W. Hunt Co., the employment of the "industrial" railway in the boiler room is discussed.

MESSRS. BAKER & CO., the platinum refineries of Newark, N. J., have sent us a number of very neat little pamphlets: The Alchemistic Symbols, a brief account of their origin and their meaning, by J. L. Howe; Durable Sparking Points for gas, gasoline and oil engines; Tucker's Combustion Apparatus for determining, with great accuracy, the volatile ingredients and total ash of any organic matter; Shimer's Combustion Apparatus for the determination of carbon in iron, steel, etc.; Sparking Points, jump-spark terminal wires and platinum ignition tubes, for use on automobiles.

THE HOLTZER-CABOT ELECTRIC CO., Boston, Mass., inform the engineering world that the proper care of their dynamo, motor and motor-generator specialities now demands all their attention. They have, therefore, discontinued the manufacture of portable, disk and ceiling fan motors of all kinds. This notice does not apply to direct-connected ventilating fan outfits. The Holtzer-Cabot Electric Co. are well known to electrochemical engineers by their high-grade electroplating dynamos, and in general, by their machines designed for special electrochemical purposes.

STEAM TURBINES.—A recent computation has placed the total aggregate power of steam turbines in use or under construction or ordered in different parts of the world at over 500,000 horse-power. Of this total the major portion is used or to be used for the driving of dynamos, alternators, or other electrical machinery, while the next in point of power consumption is marine engines. A contract was recently given to the British Westinghouse Electric and Mfg. Co., Ltd., by the Metropolitan District Railway Co., London, England, for four turbo-alternators. Each of these machines is designed for a normal capacity of 5,500 kw, but will be capable of carrying an overload of 50 per cent., giving for each unit a maximum output of 8,250 kw, or about 11,000 electric horse-power. These turbines will be not only the largest steam turbines ever made, but also the most powerful single cylinder engines of any type whatever in the world. Very few multiple cylinder engines existent have greater power. Notwithstanding the truly enormous power they will develop, the dimensions of these engines are only 29 feet in length, by 14 feet wide, by 12 feet high, the overall length of turbine and alternator being 51 feet 9 inches. The steam pressure will be 165 pounds per square inch, and the speed 1,000 revolutions per minute.

CATALOGUES RECEIVED.—Westinghouse Electric and Mfg. Co.: Folder, No. 4,011; Westinghouse fan motors, for alternating and direct-current circuits, swivel and trunnion type; a large pamphlet, special publication, No. 7,006, also on the subject of fan motors; both pamphlets are neatly illustrated. Fort Wayne Electric Works: Flyer, No. 4,043 on commutator truing devices; No. 4,044 on fan motors, suspended revolving and desk types; bulletin No. 1,039 on small direct-current generators; No. 1,040 on motor-starting rheostat, with double-release and combined switch and circuit breaker; No. 1,041 on direct-current belted motors; a booklet on perfection in transformer insulation. McGuire Mfg. Co: An illustrated catalogue of their rheostats for various uses. Osborne Flexible Co.: Several flyers on "flex duct," a flexible conduit for interior wiring.

DIGEST OF U. S. PATENTS PRIOR TO JULY, 1902.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

This digest of electrochemical United States patents prior to July, 1902, will be one by classes, setting out for comparison in each class those devices which have the same object, or those methods which seek the same results.

(Continued from page 232)

642,023. January 23, 1900; G. N. Vis, Schweizerhalle, Switzerland.

Removes calcium and magnesium from brine by electrolyzing with a curent sufficient to decompose some sodium chloride, but no calcium or magnesium salts, *e. g.*, 230 ampères at 2.4 to 5 volts per cubic meter for ten hours. The sodium hydroxide produced precipitates the calcium and magnesium. The small proportion of calcium hydroxide which re-dissolves is precipitated by injecting just sufficient carbon dioxide. May precipitate all of the calcium and magnesium as carbonates by introducing carbon dioxide immediately after electrolyzing.

647,217. April 10, 1900; A. J. O. Chalandre, L. J. B. A. Colas and C. J. Gerad, Paris, France.

Passes chlorine and hydrogen from cell of patent 511,682 into an outer chamber, where they combine. Introduces the resulting hydrochloric acid into the anode compartment to neutralize any caustic or decompose hypochlorite.

652,846. July 3, 1900; J. Hargreaves, Farnworth-in-Widnes, England.

Injects spent brine from electrolytic cell, by means of a steam jet, into and upward through a body of salt, which filters out any insoluble impurities and strengthens it for reuse. Shows an electrolytic cell of the Hargreaves type, having an electrolyzing compartment with side walls of lead, coated with pitch, against which a cement backing is cast. A row of superposed, inclined anode bars faces each diaphragm electrode, the space betwen the two rows being filled with salt.

653,933. July 17, 1900; R. Moritz, Lille, France.

Vessel consists of two rectangular support plates having opposing rims, between which a diaphragm of asbestos board or cloth is clamped. Plate at anode side may be of wood, earthenware or enameled iron; plate at cathode side of iron or stoneware. Anode, wire netting, the vertical weft wires of which may be much larger, clamped between anode plate and diaphragm. Cathode, a series of vertical carbon rods, clamped between cathode plate and diaphragm. Electrolyte is introduced on each side of the diaphragm at the lower end of the cell and flows upward in thin sheets, escaping at the upper end of the cell. Anode plate may have vertical grooves behind wire-gauze anode to distribute the stream in a thin, even layer. Carbon rods of cathode effect the same function. The bubbles of gas on the electrodes are washed off by the circulating streams.

655,343. August 7, 1900; J. Hargreaves, Widnes, England.

Improvement on cell of patent No. 596,157. Central anode chamber containing brine, with diaphragms at each side. Vessel consists of a sectional iron frame, lined with Portland cement or brick and cement. Renders lining impermeable by saturating it with paraffin, pitch or tar. Horizontal, transversely-inclined copper strips, arranged in vertical series, are bedded at one edge in the cement lining and bear at their other edges, which are serrated, against the wire-gauze cathodes, which support the diaphragms. Steam and carbon dioxide are injected into the upper ends of each empty cathode compartment and the condensed water is distributed by the serrated edges of the strips evenly over the cathodes, washing down the caustic. Perforated salt-supply device in anode compartment. Decomposes any hypochlorites or chlorates by hydrochloric acid or an oxidizable substance such as sugar or sawdust, introduced into anode compartment. Sides of vessel may be inclosed by wooden planks, to retain heat.

665,064. January 1, 1901; E. D. Chaplin and H. G. Halloran, of Boston, Mass.

Vessel of wood, having a shallow pan, serving as cathode, in its bottom. Horizontal diaphragm of cotton cloth or cloth and asbestos, stretched across upper edge of pan. A series of anode bells, each containing an annular anode of carbon or lead peroxide, depend into vessel. Each anode bell is surrounded by a wooden ring, to the lower edge of which is secured a diaphragm of cotton cloth, or cloth and asbestos, closing lower end of bell. Salt saturator in each anode bell, consisting of a porous bag, having a supply tube with feed screw.

665,953. January 15, 1901; A. J. O. Chalandre, L. J. B. A. Colas, of Paris, and C. J. Gerard, of Seveux, France.

Process corresponding to No. 647,217. Burns a sufficient amount of the evolved hydrogen and chlorine to decompose hypochlorites, when added to anode compartment. The amount of hydrochloric acid so produced is preferably 5 to 40 per cent. of the amount of caustic produced in the same time.

666,221. January 15, 1901; D. N. Hathorne and H. E. Hobson, Rumford Falls, Maine.

Diaphragm, a bag of asbestos, supported in a perforated sheet-metal vessel serving as cathode, which in turn is supported by legs in a tank. Drain pipe leads through lower end of diaphragm and cathode vessel. Tubular carbon anode, divided into four spaced sections, which are arranged near diaphragm. Centrally arranged salt saturator, consisting of a perforated, bulb-shaped earthenware vessel, removably secured to the lower end of a feed tube. Coats those portions of the diaphragm and cathode vessel which extend above the electrolyte with an inert paint.

669,441. March 5, 1901; H. A. Frasch, Hamilton, Canada.

Anode, a layer of carbon plates, lying flat on bottom of vessel and covered by a layer of matte or ore. Diaphragm, a layer of sand or ground quartz, resting upon the matte. Cathodes of carbon or copper, depending into upper portion of vessel. A pair of inlet and outlet pipes at each side of the vessel, both above and below diaphragm. Several cells may be connected in series. Circulation of electrolyte beneath diaphragm in opposite direction to the above diaphragm. Electrolytic chlorine or sulphuric acid, dissolves metal of matte, such as copper, nickel or iron, while caustic is produced at the cathode.

675,749. June 4, 1901; A. Merry and J. H. Noble, Liverpool, England.

Porous cup of earthenware, inclosed by a copper wire-gauze cathode. The cup is hermetically closed at its upper end and the brine is maintained under pressure by a suitable head, so as to force the caustic out through the pores of the cell and maintain a strong brine solution in them. Brine continuously circulated along inner wall of porous cell; may be introduced through a passage in the anode, escaping at its lower end, and being delivered from the cup through a second passage in the upper end of the anode. A tubular baffle of porous material, or a vertical series of inclined glass louvers, surrounds the anode and serves to keep chlorine away from the diaphragm. Outer vessel may contain water, if caustic is desired, or oil or other soap-making material or acid which it is desired to unite with the base.

680,191. August 6, 1901; E. A. Allen, Rumford Falls, Maine, and H. K. Moore, Lynn, Mass.

Anode chamber, a vessel of clay or iron, lined with porcelain, clay, graphite, or a chlorine substitution product of benzine. Lower end of anode chamber closed by a diaphragm of asbestos paper or cloth, beneath which is a spongy cathode of several layers of iron-wire cloth or of iron turnings or borings, resting on an iron grid. Anode, a body of broken carbon or graphite, resting on the diaphragm. Brine delivered by a float-feed device through a tube opening at the upper surface of the anode. Electrolyte continuously percolates downward through the diaphragm and exposed cathode, oxidizing and washing out the sodium.